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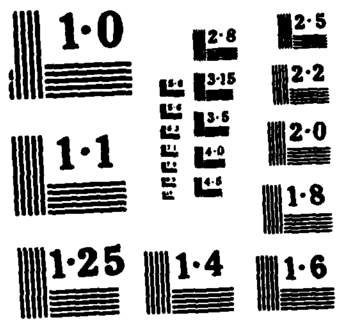

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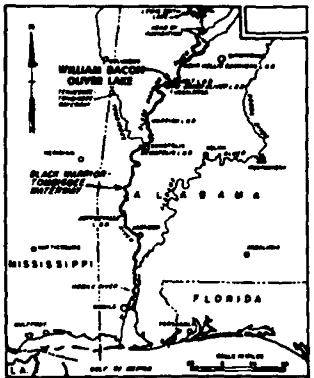

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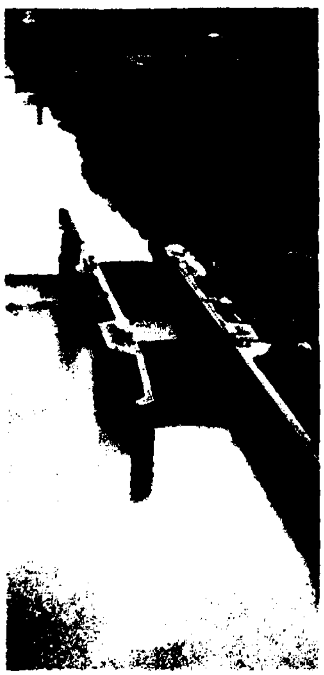

HYDRAULICS LABORATORY

MISCELLANEOUS PAPER HL-85-6

REEVALUATION OF THE OLIVER LOCK REPLACEMENT PROJECT

APPENDIX B: ECONOMICS

by

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September 1985

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for

US Army Engineer District, Mobile
Mobile, Alabama 36628

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Miscellaneous Paper HL-85-6	2. GOVT ACCESSION NO. AD-A163 256	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) REEVALUATION OF THE OLIVER LOCK REPLACEMENT PROJECT; APPENDIX B: ECONOMICS		5. TYPE OF REPORT & PERIOD COVERED Final Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Larry L. Daggett Glenda Smith		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Engineer Waterways Experiment Station Hydraulics Laboratory PO Box 631, Vicksburg, Mississippi 39180-0631		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Engineer District, Mobile PO Box 2288 Mobile, Alabama 36628		12. REPORT DATE September 1985 13. NUMBER OF PAGES 138
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Black Warrior-Tombigbee Waterway (WES)
Inland water transporation--economic aspects (LC)
Inland water transportation--evaluation--methodology (LC)
Oliver Lock Replacement Project (WES)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A systems analysis of the inland waterways that affect or that might be affected by the replacement of the Oliver Lock on the Black Warrior River was conducted to determine the benefits (or costs) of such a replacement. The present lock is smaller than the other locks on the Black Warrior-Tombigbee (BWT) Waterway and is a major point of congestion and delay to tow traffic. The analysis of the benefits of replacing this lock is complicated by the opening of the Tennessee-Tombigbee Waterway (TTW), which junctions with the BWT just above Demopolis Lock and Dam. This brings together traffic from two waterway systems on an existing waterway with two locks and many difficult bends.

In order to conduct such an analysis, an evaluation methodology and procedure had to be developed to measure total system performance. By evaluating the economic performance of the system for the existing and

(Continued)

20. ABSTRACT (Continued).

proposed improvement at Oliver Lock and Dam, the marginal system benefits attributable to this improvement can be measured. Project feasibility and benefits can then be determined.

In analyzing a lock and dam project, the interdependence of traffic flows between the many individual elements of the system must be taken into account. A change in the performance capabilities of one lock or channel segment can affect the efficiencies of other components in at least two ways--by increasing aggregate service demands at other structures, and by changing the economic and physical characteristics of the traffic. Conversely, the capabilities of other components of the system can restrict traffic flows at the project under study and prevent the materialization of expected benefits. Both situations were very real factors that had to be accounted for in this investigation.

The modeling system employed in this study consists of a series of interlinked computer programs and simulation models. The basic components of the system are the Tow Cost Model (TCM), the Waterway Analysis Model (WAM), and the Marginal Economic Analysis (MEA) Postprocessor. The TCM is a fleet sizing and costing program that is used to measure differences in the cost characteristics associated with different traffic levels and different system definitions. The TCM depends on accurate definition of the system capacities and delays at congestion points to accurately determine the operation costs. However, capacity and the resulting delays are strongly affected by the fleet makeup and commodity movement demands. Therefore an interface was developed that allowed the WAM to simulate the system response to the traffic generated by the TCM based on the projected traffic movements. The WAM can then determine the utilization of the locks and the resulting delays by simulating in detail the lockage operations required to service the traffic movements generated by the TCM. In addition, the WAM was extended to determine the effects of constrained reaches of the waterway on the channel transit times. By iterating between the TCM and the WAM, it is then possible to obtain an accurate measure of the changes in system costs and to estimate the incremental changes in waterway rates under the conditions tested. The MEA Postprocessor was used to evaluate the resultant impacts on transportation rate savings and to determine system traffic levels by measuring the effects of alternative improvements, the resulting traffic demand scenarios, and traffic diversions.

The waterway system used in this investigation included the BWT, the Gulf Intracoastal Waterway System, and the Lower Mississippi, the Lower Ohio, the Tennessee, and the Cumberland Rivers. The Upper Mississippi, Missouri, Arkansas, Kanawha, Green, Monongahela, and Alabama Rivers and the Illinois Waterway were included in the system also, however, at a much lower level of detail. For the future year analyses, the system also included the TTW.

The systems analysis study demonstrated that the benefits resulting from the replacement of the Oliver Lock continue to be large even with the TTW traffic sharing the lower BWT. Another important result of the analysis is the identification of locks in the system that cannot process all of the projected traffic. It was found that the Inner Harbor Navigation Canal Lock could not pass the projected traffic in even the first future year, 1990. Kentucky/Barkley and Chickamauga Locks were found to reach capacity early in the simulated future. The Kentucky/Barkley Locks were found to have the most influence on constraining TTW traffic and not Demopolis or Coffeeville Locks on the BWT. The constrained bends on the lower BWT that were of initial concern proved not to be a serious constraint.

PREFACE

This investigation was performed by the Hydraulics Laboratory of the US Army Engineer Waterways Experiment Station (WES) for the US Army Engineer District, Mobile (SAM). The study involved making major modifications to one of the Inland Navigation System Analysis models, the Waterways Analysis Model (WAM), and development of an integrated economic and simulation analysis modeling system. The economic analysis model was modified from one developed by the US Army Engineer District, Huntington (ORH), and the basic waterway network model and data for the Tennessee and Cumberland Rivers were obtained from a model developed by the US Army Engineer District, Louisville (ORL). Data analysis programs used to develop basic model data from the historic lockage data base, Performance Monitoring System (PMS), were also obtained by modifying programs developed by ORL. The development and adjustment of the specific model used in the analysis and the analysis of the economic benefits and costs of the system were a joint effort of WES and SAM. Authority for the investigation was given by SAM in SAMPD-N letter of 7 July 1981. Results of this study were included in Appendix B of the Interim Feasibility Report and Environmental Impact Statement for Oliver Lock Replacement published in June 1983.

The investigation was conducted by Dr. Larry Daggett and Mrs. Kathren M. Eagles of the Mathematical Modeling Group, under the general supervision of Messrs. H. B. Simmons and Frank A. Herrmann, Jr., former and present Chiefs of the Hydraulics Laboratory, and M. B. Boyd, Chief of the Hydraulic Analysis Division. A major participant in the conduct of the investigation and a coauthor of this paper was Mrs. Glenda Smith, SAM, under the general supervision of Messrs. Lawrence Green, Chief of the Planning Division, and William Herran, Chief of the Economics Branch.

Acknowledgment is made to Mr. Robert Meader, Central Projects Branch, Planning Division, SAM, for his cooperation and assistance at various times throughout the investigation. Special thanks should go to Mr. Ron Keeney, Chief of the Navigation Planning Support Center, ORH; Mr. David Weekly, Engineer, Navigation Planning Support Center; and Mr. Steve Vierling, Engineer, Navigation Planning Support Center, ORL, for their assistance and guidance throughout this investigation. Appreciation is expressed to Mr. Jim Wassel of Boeing Computer Services who, under contract, modified the WAM.

Finally, special thanks should go to the Black Warrior Waterways Association for their support in the tow transit survey conducted during this investigation. This report was edited by Mrs. Beth F. Vavra, Publications and Graphic Arts Division.

COL Tilford C. Creel, CE, and COL Robert C. Lee, CE, were Commanders and Directors of WES during the conduct of the study. COL Allen F. Grum, USA, was Director of WES during the preparation and publication of this report. Mr. Fred R. Brown and Dr. Robert W. Whalin were Technical Directors.

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SECTION I

INTRODUCTION

PURPOSE

This appendix contains detailed data and analyses of the transportation economics analyses pertaining to a reevaluation of the Oliver Lock Replacement Project. The following sections and attachments document the evaluation procedures and provide estimates of the National Economic Development (NED) benefits which are expected to result from the proposed project.

The primary aim of this study was to estimate the navigation benefits which would reasonably accrue to the Oliver Lock Replacement over a 50-year project life (1990-2039). Cost and benefit data contained herein reflect October 1982 price levels. Average annual benefits were computed using a 7-7/8 percent interest rate.

SYSTEMS ANALYSIS

A major problem in the economic evaluation of a lock and dam project is the interdependence of traffic flows between the many individual elements of the system. In a system as diverse as the inland waterway system, a change in the performance capabilities of one lock or channel segment can affect the efficiencies of other components in at least two ways--by increasing aggregate service demands at other structures, and by changing the economic and physical characteristics of the traffic. Conversely, the capabilities of other components of the system can restrict traffic flows at the project under study and prevent the materialization of expected benefit streams.

The evaluation methodology and procedures employed in this study have been developed to measure total system performance. By evaluating the economic performance of the system for the existing and proposed improvement at

Oliver Lock and Dam, the marginal system benefits attributable to this improvement can be measured. The project feasibility and benefits can then be determined.

For purposes of economic evaluation, the "system" is defined as the Black Warrior-Tombigbee (BWT) Waterway, the Gulf Intracoastal Waterway (GIWW) System, and the Lower Mississippi, the Lower Ohio, the Tennessee and the Cumberland Rivers. The Upper Mississippi, Missouri, Arkansas, Kanawha, Green, Monongahela, and Alabama Rivers and the Illinois Waterway were included in the system, however, at a much lower level of detail. For future year analyses, the system also included the Tennessee-Tombigbee Waterway (TTW), which is now under construction. The system should be viewed both from the context of the waterways' physical network, as described above, and the transportation infrastructure which utilizes this network.

The modeling system employed in this study consists of a series of interlinked computer programs and simulation models. The basic components of the system are the Tow Cost Model (TCM), developed by CACI, Inc., and modified by the Huntington District, Corps of Engineers (COE), and the Waterway Analysis Model (WAM) also developed by CACI, Inc., and modified extensively by the US Army Engineer Waterways Experiment Station (WES) and the Boeing Computer Services under contract to WES.

The TCM is a fleet sizing and costing program that is a modified and expanded version of the original Flotilla Model, conceived as a part of the COE Inland Navigation System Analysis (INSA) program. The TCM is used to measure differences in the cost characteristics associated with different traffic levels and different system definitions. The model is static; therefore iterative processing is required for introduction of the dynamics of time and change in traffic demands. Because the TCM uses values of capacity and a description of the delay relationship that are generated external to the model and because these factors are very important to the costs that are determined, an accurate means of determining these factors is required. However, capacity and the resulting delays are strongly affected by the fleet makeup and commodity flow patterns that are developed based on the system performance and commodity movement demands. Therefore an interface was developed that allowed

the WAM to simulate the system response to the traffic generated by the TCM based on the projected traffic movements. The WAM would determine the utilization of the locks and the resulting delays by simulating in detail the lockage operations required to service the traffic movements generated by the TCM. In addition, the WAM was extended to determine the effects of constrained reaches of the waterway on the channel transit times. By iterating between the TCM and WAM, it is then possible to obtain an accurate measure of the changes in system costs and to estimate incremental changes in waterway rates under the conditions tested. For purposes of evaluating the resultant impacts on transportation rate savings and determining system traffic levels, a Marginal Economic Analysis Postprocessor was developed by the Huntington District, COE. By iterative use of this procedure, the effects of alternative improvements, the resulting traffic demand scenarios, and traffic diversion criteria can be measured.

The purpose of this appendix is to provide an explanation of the steps involved in the procedures developed and the rationale used in the application. The information contained focuses on the general applications but stops short of a detailed description of the models. Additional information on the models and their application is available at the Mobile District, COE.

SYNOPSIS

Section II, entitled Model Process, describes the system used for this study and the sequential steps involved in determination of NED benefits. A flow diagram is provided and the paragraphs are keyed to applicable segments of the diagram.

Section III, entitled Model Application, describes in detail the actual modeled system. This includes discussing the generation of the shipment list and the projected traffic. All of the required model input data is described, as well as the sources and how the data were derived. Finally, the calibration of the model is discussed.

Section IV, entitled Results, describes the basic results of the systems analysis study. It discusses the overall results and the lock capacities that

were observed under the various conditions. Finally, the system tonnages and benefits are presented.

Section V, entitled Required Sensitivities, contains the results of the various sensitivity tests required by Principles and Guidelines, ER-1105-2-40, dated 8 January 1982. This includes the 20-year project growth benefits, operations and maintenance cost recovery fees, capital cost recovery fees, and congestion fees.

Attachment 1, entitled Systems Analysis, provides a complete overview of the waterway system and a general description of the characteristics of the waterway system operations. A discussion of the waterway service cost components and their sensitivity to traffic levels and system changes provides a basis for understanding the need to perform systems analyis studies.

Attachment 2, entitled Economic Model Conception, discusses applicable economic theory. An effort is made first to define the general nature of the supply-demand relationships for the system and towing industry, and to show the relative importance of system characteristics on the waterway's production function. It also includes a discussion of the development of the system's unconstrained freight-flow projections, the rate estimates, and waterway service cost analysis.

Attachment 3, entitled Background on System Model Development, describes the historic development of existing models and the system selected for this study. It describes the shortcomings of existing models for use in the Oliver Lock Replacement Project and the modifications necessary to develop an acceptable systems analysis model.

Attachment 4 contains the data described in Section III. These tables were considered to be too voluminous for inclusion in the main body of the appendix.

This appendix is not intended to provide the necessary information to fully understand the detailed operations of the models used in the study.

SECTION II

MODEL PROCESS

SYSTEM SELECTED FOR THIS STUDY

Even though the Oliver Lock Study is focusing on improvement at just one small segment of the inland waterway, that improvement can have a much broader impact on surrounding segments of the system. Such is the case with Oliver. Even though the major impact of replacing Oliver is limited to the BWT Waterway, especially at Demopolis and Coffeeville Locks, the secondary impact reaches well beyond this area.

Based on the origin and destination patterns of affected traffic, the impacted system included the BWT Waterway, the TTW, the East GIWW, and the Lower Mississippi, Lower Ohio, Tennessee, and Cumberland Rivers. The Upper Mississippi, Upper Ohio, Missouri, Arkansas, Kanawha, Green, Monongahela, and Alabama Rivers, the Illinois Waterway, and the West GIWW were also included in the defined system but at a much lower level of detail.

Figure B-II-1 depicts the inland waterway system considered in the Oliver Lock Replacement Project. The portions of the system modeled in detail are delineated by the darkened locks.

MODEL FLOW DIAGRAM DISCUSSION

Figure B-II-2 presents a diagram of the sequential modeling process used to analyze the Oliver Lock replacement study. Discussion on the various steps involved in this modeling process are contained in the following paragraphs which are numbered to correspond with items in the flow diagram.

1. Shipment List - The shipment list is a data base of all dock-to-dock annual commodity movements reported for the impacted system to the Waterborne Commerce Statistics Center for the calendar year 1979. These data also include the forecasted values for each movement based on 1980 OBERS projections developed by the Office of Business Economics. The movements projected in the 1976 Economic Reanalysis to move on the TTW were then added to the shipment list.

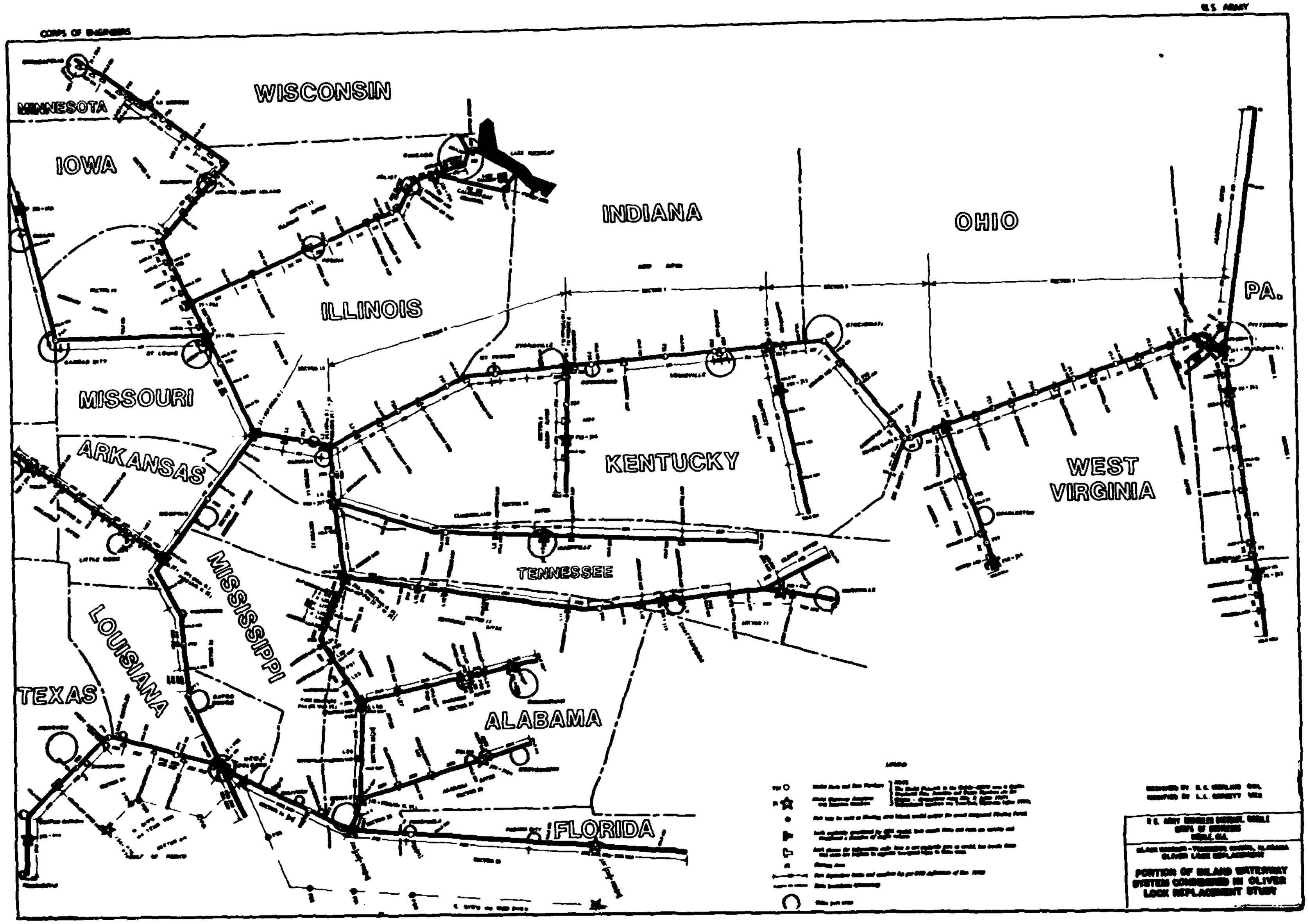

Figure B-II-1. Portion of inland waterway system considered in Oliver Lock Replacement Study

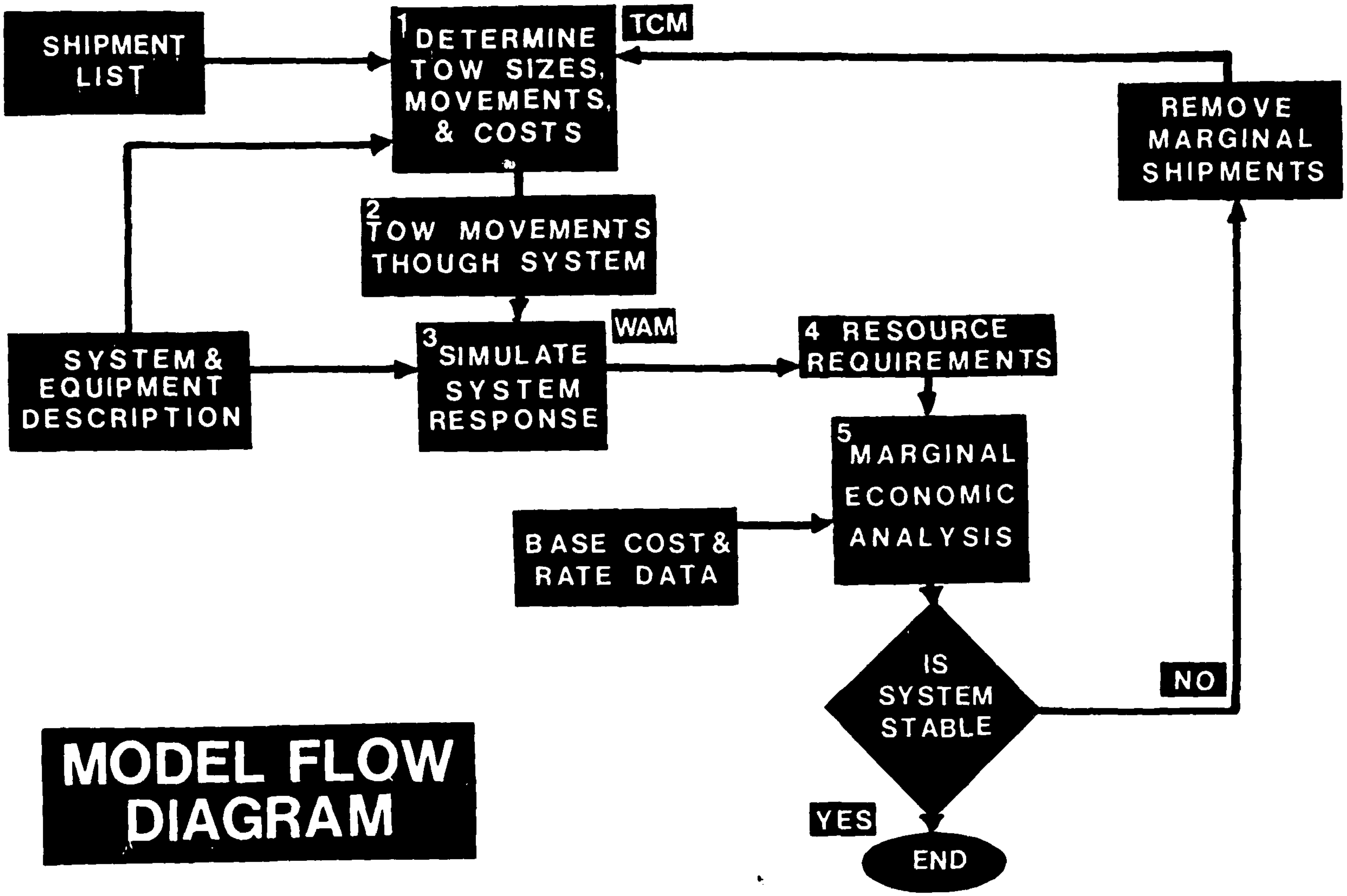

Figure B-II-2. Model flow diagram

2. System and Equipment Description - The system and equipment description is a data base containing detailed information on the physical characteristics of the impacted system as well as cost and physical characteristics of the major commodity, transportation towboat, and barge classes. Information on the impacted system includes lock dimensions and timings, port characteristics, river segment characteristics, fleeting points, and bend and bridge dimensions. This data served as input into both the TCM and WAM models.

3. Tow Cost Model - The TCM optimizes the use of towing equipment based on the cost of movement through the waterway system for each year studied. The cost of movement is determined by the traffic characteristics in any given year. The pattern and volume of traffic in the system affect the opportunities for backhaul and the congestion at points of constraint (primarily locks). Normally as the costs of movement increase, the TCM generated tow size also increases. A maximum allowable tow size was specified for each river segment, based on physical characteristics. The TCM tow size will not grow beyond this level.

4. Tow Movements Through System - The tow movements through the system is a tow generation program which utilizes the optimized towing equipment output and shipment list from the TCM. This program randomly generates movements which are input to the WAM. By utilizing the TCM output, the towing equipment is moving as efficiently as possible based on the system constraints and traffic patterns for each year analyzed. Generated data include number of roundtrips, towboat class, barge type and tow size selected, barge load allowed, and empty backhaul factor for each segment of a transportation class movement.

5. Waterway Analysis Model - The WAM simulates the system response to the randomly generated traffic movements. Statistics on the timing and delays encountered in each segment by each generated dock-to-dock movement event are determined and recorded. For the purpose of analyzing the impact of replacing Oliver, a method of modeling tow transit through constricted bends was added to the WAM. Based on the traffic characteristics in any given year, the delays encountered as traffic increases at constraint points (locks, bends, and bridges) are added to the base condition (1979) times of each movement.

The percent utilization and delays encountered at each lock in the impacted system is an output of this model. For each year studied, the lock utilization and capacity are determined based on the traffic characteristics at each lock. For those locks experiencing congestion (Kentucky-Barkley, Inner Harbor Navigation Channel (IHNC), Oliver, Coffeeville, and Demopolis), various combinations of nonstructural improvements, primarily lock operating policies, were tested to determine those with the greatest influence on increasing the lock capacity.

6. Resource Requirements - The resource requirements file contains the detailed movement data output from the WAM. It contains the number and tonnage volume of movements and associated transit times through various segments of the impacted system. This file contains the data on encountered delays that is used as input to the Marginal Economic Analysis (MEA) program which is used to determine the benefits attributable to the project implementation.

7. Base Cost and Rate Data - The base cost and rate data are contained in a file which is used as input to the MEA program. The rates reflect 1 October 1982 price levels and are associated on a one-to-one basis with all the movements in the shipment list. In addition, the base costs associated with each movement's transit through the system in 1979 are also contained in the file.

8. Marginal Economic Analysis - The MEA program uses costs associated with transit, locking, and delay times as developed by the TCM or as modified by the WAM. As delays increase with growth in traffic levels or, as the system efficiency is improved through nonstructural or (in the case of Oliver) structural modifications, the base rate as determined in the rate survey is modified to reflect the resulting changes in linehaul costs. The MEA displays the transportation class movements ranked in order of decreasing marginal rate savings. It also displays traffic, cost, and rate savings data for movements common to user specified reaches of the impacted system. In this case, specified reaches were the BWT System, and Oliver, Coffeeville, and Demopolis Locks. If the system is stable, e.g., congestion is not building anywhere in the system and the delays encountered are what the traffic will bear, the

results of the MEA determine the benefits. However, if the system is not reflecting a stable level of traffic, some movements need to be diverted and the entire modeling process is repeated until stability is achieved.

9. Remove Marginal Shipments - The remove marginal shipments step involves use of a diversion procedure.

The diversion procedure used in this study is based primarily on the marginal rate savings determined by the MEA analysis. The diversions are iterative. The diversion process involves two steps:

a. To reduce the projected traffic to a level within the capacity of a lock.

b. To eliminate movements with negative rate savings.

Movements that are "diverted" are in fact removed from the waterway shipment list even though the rate savings may have been based on an alternate waterway routing. Thus diversion means removal from the inland waterway system. Because of the origin-destination pattern of the TTW movements (the only movements within an alternative waterway routing), the rerouting would not impact the TTW-BWT system locks. The rerouted TTW movements would begin or terminate at points on the BWT below Coffeeville, usually at Mobile, Alabama, or along the GIWW east of Mobile.

To bring a lock(s) into a level of traffic that can be processed by the lock(s), a tonnage level to be removed from the traffic passing through the lock(s) is specified. The shipment list is then reduced by the movements with the most negative rate savings per ton-mile being removed first. The procedure is accomplished in two passes. The first pass identifies the movements that pass through each lock having traffic reduced until each lock's requirement for tonnage reduction is met, starting with the movement with the largest negative rate savings per ton-mile value. Then a second pass is made through this subset of traffic, reordering the movements so that those movements that pass through more than one lock having traffic removed are selected first. Traffic is removed until each lock's traffic is reduced to the desired amount. If the last movement selected is larger than the amount required, the amount of tonnage remaining after satisfying the required reduction is left in the shipment list, i.e. the movement is split.

To reduce the traffic to a point that essentially no traffic remains on the system moving with negative rate savings, traffic movements are removed starting with the movement with the largest negative rate savings per ton-mile and working up the list until a desired level of traffic reduction is reached. Since the removal of this traffic will reduce operating costs for remaining traffic and, hence, some movements with negative rate savings could begin to operate with a positive rate savings, the reduction of traffic is accomplished in small iterative increments.

SECTION III

MODEL APPLICATION

MODEL INPUT DATA

The system definition used in this study is largely based on the system description used in the study of the Lower Ohio River system conducted by the Louisville District. This system was redefined to model the BWT and TTW in more detail and to reduce the emphasis on the Upper Ohio River and its tributaries. The major system components include the BWT, TTW, Tennessee, Cumberland, Lower Ohio, Lower Mississippi Rivers, and the East GIWW. The Upper Mississippi, Missouri, Arkansas, and Upper Ohio Rivers and tributaries and the Illinois Waterway and West GIWW are modeled to less detail, basically including representative reaches, ports, and junctions. Locks on the Upper Mississippi, Illinois Waterway, Upper Ohio and tributaries, and West GIWW are not represented explicitly.

This section will describe the model data required and identify the source of information used to obtain the data.

SHIPMENT LIST

The shipment list was derived from detailed dock-to-dock records reported to the Waterborne Commerce Statistics Center (WCSC) of the calendar year 1979. This was the latest data available at the time the study was initiated. Each record was encoded with the origin and destination Port Equivalent (PE) and Business Economic Area (BEA) codes in which the respective dock was located. The PE definitions used are the INSA definitions and were derived from an updated waterway point directory developed by this project. Using the BEA and the commodity codes, each record was assigned projection rates for the years 1990, 2000, 2010, 2020, and 2030. The projection factors were based on the 1980 OBERS projections developed by the Office of Business Economics. The movements projected to move on the TTW in the 1976 Economic Reanalysis of the TTW were then added to these movements. The projected movements are shown in Table 1 in Attachment 4.

These records were then processed by a series of programs that prepared the shipments for use in the model. All movements that did not move on the primary systems being analyzed or through the locks included in the study were eliminated to reduce the size of the shipment list. PE's were converted into the port code used for the models, and commodities were grouped into common classes. All movements with common origin and destination ports and commodity groups were aggregated into a single record, further reducing the size of the list. The selected year's projection factor was then applied to the aggregated tonnage and a shipment list for that year produced. Records with less than 6,000 tons were dropped from the list since it was found that these movements accounted for less than 1 percent of the total movements and removing them reduced greatly the size of the data files and the cost of executing the models runs. Dedication factors for particular movements were then added to the shipment record. The shipment list is now ready for use with the TCM.

SYSTEM DIMENSIONS

The system used in this study is a large system. It contains:

1. 20 river systems
2. 34 sectors
3. 111 ports
4. 29 locks
5. 31 chamber classes
6. 180 reaches
7. 73 bends
8. 15 commodity classes
9. 10 transportation classes
10. 5 towboat classes
11. 6 barge classes

These system components are the same in the TCM and WAM and will be described below.

COMMODITY CLASSES

The WCSC commodities were grouped into 15 compatible classes for use in this study. The classes are the ones developed in earlier BWT and TTW analyses. For each commodity group a weighted average commodity value, holding or inventory factor, and density were developed from the values found for each of the individual commodities in the class weighted by the proportion of the total class tonnage. Also each commodity was assigned to a transportation class, which is described below. The commodity data used are shown in Table 2 in Attachment 4.

TRANSPORTATION CLASSES

The commodity classes are assigned to transportation classes in order to allow more efficient use of equipment. The transportation classes are made up of commodities that are compatible and that use similar types of equipment. Transportation classes are allowed to make use of the barges in backhaul situations when the opportunity exists. Each transportation class is assigned a handling class that determines the loading and unloading rates at the ports for the commodities. Handling classes were used to distinguish between liquids, dry bulk, and granular bulk. The transportation class descriptions used are shown in Table 3 in Attachment 4.

TOWBOAT CLASSES

The operating fleet was represented in this study with five towboat groupings. Two 1,800-hp towboat classes were used to represent the motor vessels used on the BWT on the TTW. The difference in the description of these classes is the maximum tow each is allowed to push: the BWT tows are limited to 6-barge units and the TTW are allowed to push 8-barge tows. A 3,100-hp and a 4,200-hp towboat represented the pusher units operating on the major rivers and their tributaries such as the Ohio and Upper Mississippi Rivers. A much larger unit was included to represent the larger class of motor vessels operating on the Lower Mississippi where tow sizes are typically much larger than other waterways.

Each towboat class is assigned a pushing power, a maximum tow size, dimensions, fuel consumption, and variable and fixed costs. The dimensions used were typical of towboats of the horsepower range of the class. The fuel consumption and costs of operation were derived from data furnished by the Office, Chief of Engineers (OCE). These data are presented in Table 4 in Attachment 4.

BARGE CLASSES

The barge classes are used to describe the equipment used to move the commodities. When specialized equipment is used to move particular commodities, this equipment is usually dedicated to that particualr commodity class. Six barge classes are used in this study. Many of the commodities on the BWT are moved in jumbo hopper barges. Petroleum is the primary commodity observed that uses superintegrated barges. Therefore, the nominal barge class is defined as the jumbo barge.

A loading capacity, dimensions (including a loaded and empty draft), and variable and fixed costs are assigned for each barge class. Availability factors and substitutable barges can also be defined. Again the costs for the barge classes were obtained from the OCE-furnished information. The barge characteristics used in this study are shown in Table 5 in Attachment 4.

PORT DEFINITION

The port definitions used in this study are basically the same port definitions used in the Louisville study. The differences occur in two places. The BWT and TTW port definitions used in the Lower Ohio River study were expanded to include a port for each lock pool on the BWT and one for the BWT below Coffeeville Lock and Dam. Also the port definitions used to define the alternate routing possibilities were modified to allow a more appropriate emphasis on the routing potentials. The ports were defined as groups of PE's. Typically all PE's in a lock pool were included in a single port unless a PE is on another river system. Ports are used primarily for defining the points of origin and destination of movements, for routing information, and for loading and unloading operations and statistics. The port definitions

used in this study are shown in Figure 1 located in Attachment 4.

Each port is assigned the following properties:

1. A barge pickup/dropoff time including a fixed tow turnaround time.
2. A loading and unloading rate for each of the handling classes.
3. An average port delay experienced for each tow.
4. An average towboat waiting time.

Since the ORD studies had conducted surveys in order to determine normal port characteristics and no additional data were available, the values used for these parameters in the Louisville study were used here. The characteristics are shown in Table 6 in Attachment 4.

LOCK DEFINITION

The lock definitions used in this study were selected to identify the interactions of BWT and TTW traffic with the traffic at other locks in the system. Thus the 29 locks used in this study include all of the locks on the BTW, TTW, and the Tennessee River and the first locks on the connecting waterway routes. Both Locks and Dams 52 and 53 are included because both locks are subjects of ongoing studies for improvement and potentially could be affected by the availability of the TTW.

Because of the importance of the locking times and delays to the system analysis results, considerable effort was committed to obtaining the best data available to describe the lock and chamber characteristics. A complete analysis of the BWT Performance Monitoring System (PMS) data for 1979 was performed using LOCKOP and JUNIBLD programs developed by the Louisville District. In addition, the PMS data for 1980, 1981, and 1982 were analyzed for this system. The PMS data for 1980 from the IHNC lock were also analyzed in detail using the same programs. Data for the existing TTW locks from 1980 and 1981 were analyzed also; however, there were very few lockages performed at these locks. LOCKOP results for selected locks on the Tennessee River for 1980 were obtained from an analysis that Louisville was performing at the time data were being gathered for this modeling effort. Locks included in this analysis were

Kentucky, Barkley, Pickwick, Wilson, and Chickamauga locks. A special LOCKOP report was available for a short period at Wilson Locks when the main chamber was down for repair work and the auxiliary chamber, which is rarely used, was being used for locking. No PMS data were available for the Smithland Locks since they had not been functioning for the time period that valid PMS data were available. The latest PMS data available for the Locks and Dams 52 and 53 were from 1976; Louisville District did not recommend using PMS data after that year.

The results from these annual PMS reports were used to derive the data required for the TCM and WAM models for the BWT and IHNC and Tennessee River locks. For those locks on the Tennessee River that were not included in the analysis, estimated values were derived from those locks most nearly compatible with the missing locks' characteristics, considering primarily the adjacent locks in order to maintain compatible traffic characteristics. The Smithland Locks and the Locks and Dams 52 and 53 information was obtained from the Lower Ohio River study input data.

The method of modeling the Kentucky and Barkley Locks and Dams requires special notice. Since the TCM does not allow direct modeling of networks with loops, it was not possible to model exactly the Lower Ohio, Tennessee, and Cumberland Rivers and Barkley Canal Loop. However, because the Barkley Canal is relatively short and since the Kentucky and Barkley pools are essentially one pool, the Kentucky and Barkley Locks were modeled as a dual chamber lock. This is the same procedure used in the Lower Ohio River analysis.

Most of the locks in the system were assigned a first-in/first-out operating policy. Demopolis and Coffeeville were assigned a policy of 1-up/1-down since this was found to be more efficient. Kentucky/Barkley, Chickamauga, IHNC, Demopolis, Coffeeville, and Oliver Locks were modeled with detailed lockage times, while all others were modeled using the simplified lockage time computations. Using detailed lockage times allowed the modeling of multi-vessel, ready-to-serve lockage policies and recreational traffic. Recreation traffic was modeled at IHNC in an attempt to account for the large number of lightboat and miscellaneous traffic that passes through that lock. No open-pass conditions were modeled but these operations were implicitly included in Locks and Dams 52 and 53 lockage times.

For future years without project conditions, operational characteristics at Demopolis, Coffeeville, and Oliver were modified. The locking times were shortened to reflect estimated improvements in approach times with increased efficiency of operations at these locks and the installation of mooring cells where feasible to assist in the lockage process. In addition, the lock size and timings were changed for the Oliver Lock for the future years with the project to represent the design lockage component times. The new lock chamber being constructed at Pickwick Lock was also included in future year runs.

The details of the locking input data used for the calibration conditions are displayed in Tables 7, 8, 9, and 10 in Attachment 4.

RIVER SEGMENT DEFINITION

Statistics generated during the modeling can be aggregated and reported as river systems. As noted earlier, 20 river segments were defined for this study. A listing of these segments is presented in Table 11 in Attachment 4.

SECTOR AND LINK DEFINITION

River segments are made up of groups of sectors. The sectors consist of groups of links connecting ports, locks, and junctions. Thirty-four sectors were defined in this study. Each sector consists of ports, locks, bends, and river reaches. A sector will normally have some consistent characteristics that are defined when the sector is defined. A name is assigned to each segment and the sector is assigned to a river segment. Properties such as the average current speed, the average and minimum depths, tow speed coefficients, maximum tow size, and towboat capacity are defined for that sector. Each link is defined by the beginning and ending node, which is either a port, lock, junction, or bend terminator. The characteristics of the reach are defined in the same manner as the general sector characteristics. The additional data item required is the length of the sector. Bends also require the definition of the bend radius, width, clearance width, and maximum tow length before requiring a flanking operation. A special prototype study was conducted to determine the transit speeds through the bends as a function of the bend radius and navigation conditions. The sector and link definitions used for

this study are presented in Table 12 in Attachment 4.

ROUTE SPECIFICATION

The sequence of sectors to be transited in order to proceed from the origin port to the destination port is defined in the route specification table. It is this table and the use of dual port definitions for particular sectors, i.e., the GIWW, that allows the routing of some traffic via the Lower Mississippi and some via the TTW. The definitions used are presented in Table 13 in Attachment 4.

MODEL CALIBRATION

The calibration of a simulation model is an important step in the study process. In this study the calibration procedure primarily involved the TCM. The calibration involves comparing the model results with the observed characteristics of the system and adjusting characteristics of the model so that it more closely represents the observed conditions. Properties used for evaluation of the model's performance in this process included the tonnage passing through the locks, the number of tows and barges locked, the distribution of lockage types, the distribution of tow sizes and loading of tows, the percent of empty barges locked, and the utilization of the lock. The following changes were made in the calibration process:

1. Increased the capacity and draft of the barges types.
2. Replaced the 1,000-hp tow type with an 1,800-hp tow type with a 6-barge capacity.
3. Adjusted the dedication factors on the BWT and the IHNC.
4. Changed the maximum tow size on the BWT and IHNC.
5. Adjusted the routing on the Lower Ohio River.
6. Increased the density of coal.
7. Relocated the fleeting point between the TTW and the Tennessee River.

Though it would be desirable to have multiple years in the calibration verification, the data were not available to run multiyear tests. Due to the unavailability of acceptable 1979 PMS data at IHNC, 1976 and 1980 data had to

be substituted for calibration purposes. PMS data problems were encountered at other locks in the system, including 52, 53, and Smithland. It was also found that PMS data problems were present in other years at various locks throughout the system. In view of the overall problems, the 1979 data were considered to be most appropriate for the calibration process.

The results of the calibration presented in Table B-III-1 compare the values obtained from PMS and lockmaster data with the values obtained from model calibration runs. With the exception of the problems discussed in the following paragraphs, the calibration produced acceptable results. Further investigation of the problem areas (IHNC, Oliver, and Chickamauga) revealed that the level of difference was explainable and/or within an acceptable range.

As mentioned previously, the TCM is an optimization model which determines the optimum tow size for a system considering the cost per movement on any given segment of the system. The towing industry, not having knowledge of the market at all times, lags behind the optimum tow size. TCM determined that a 3.9-barge tow size was the optimum for BWT traffic based on the cost characteristics of movement in 1979. The actual average tow size for the waterway in that year was 3.5. However, in 1980 the average tow size did in fact grow to 3.9 barges per tow in May and June. Average tow size for 1980 was 4.1 barges per tow. The effect of the larger tow sizes on all locks other than Oliver is a decrease in the percent utilization since fewer tows, and hence lockages, were required for the given level of tonnage. However, due to the increase in double lockages resulting from more 4- and 6-barge tows, the utilization at Oliver would be higher. The TCM results reflect this relationship. A functional relationship of utilization to tow size was developed based on the actual experienced utilization associated with average tow sizes in 1979 and various months in 1980 and 1981 and is presented in Figure B-III-1. The percent utilization at Oliver associated with a 3.9-barge tow would be approximately 48 percent. This compares to a 44 percent utilization computed by TCM.

It should be noted that the 44 percent utilization represents an unimproved Oliver with no nonstructural improvements since none were in use in

Table B-III-1

CALIBRATION RESULTS

LOCK	TONNAGE (MTONS) FMS	TONNAGE (MTONS) TCM	TOWS FMS	TOWS TCM	BARGES FMS	BARGES TCM	EMPTY FMS	EMPTY TCM	% UTILIZATION FMS	% UTILIZATION TCM	DELAY (HR) FMS	DELAY (HR) TCM
L&D 53	57.418	60.417(5.2)	8204	7998(-2.5)	---	69056	--	43	--	18	---	0.3
L&D 52	65.870	70.748(7.4)	10110	9324(-7.8)	76836	79139(3.0)	--	38	--	28	---	2.6
SMITHLAND	64.717	68.392(5.7)	---	9646	---	80613	--	41	--	40	---	0.7
IHNC	22.286	21.056(-5.5)	12460	11329(-9.0)	27412	24664(-10.0)	49	50(1)	85	81(-4)	4.4	4.6
KENT/BARK	31.515	31.051(-1.5)	4456	4539(1.9)	40263	39299(- 2.4)	47	46(1)	52	49(-3)	3.2	2.8
PICKWICK	14.867	14.749(-0.8)	1979	1769(-10.6)	20254	18912(- 6.6)	45	45(0)	--	44	1.0	1.1
CHICKAMAUGA	1.518	1.150(-24.2)[c]	426	371(-12.9)	2224	1613(-27.5)	48	47(-1)	29	26(-3)	0.7	0.7
WILSON	7.932	7.341(-7.5)	1177	971(-17.5)	9016	8489(- 5.8)	40	39(-1)	32	23(-9)	0.4	0.5
BANKHEAD	9.543	9.589(-0.5)	2230	2348(5.3)	8006	9144(14.2)	31	23(-8)	20	22(2)	0.2	0.1
HOLT	11.796	11.990(1.6)	2823	2951(4.5)	10428	---	29	30(1)	27	23(-4)	0.3	0.2
OLIVER	11.948	12.230(2.4)	3075	3032(- 1.4)	10872	11876(9.2)	29	31(2)	48[a]	44(-4)	0.9	0.8
WARRIOR	12.078	12.398(2.6)	3032	3087(1.8)	10765	---	29	31(2)	25	21(-4)	0.3	0.2
DEMOPOLIS	11.531	11.783(2.2)	2820	2942(4.3)	10426	11481(10.1)	28	30(2)	25	20(-5)	0.3	0.1
COFFEEVILLE	11.954	12.115(1.3)	3080	3059(- 0.7)	10897	11961(9.8)	29	30(1)	24	21(-3)	0.1	0.2

CALIBRATION RESULTS (Part 2)

LOCK	TONS/TOW FMS	TONS/TOW TCM	BARGES/TOW FMS	BARGES/TOW TCM
L&D 53	---	7554	---	8.6
L&D 52	6515[b]	7588(16.5)	7.6	8.5(11.8)
SMITHLAND	---	7090	---	8.4
IHNC	1768	1859(-5.1)	2.2	2.2(0.0)
KENT/BARK	7028	6841(- 2.7)	9.0	3.7(- 3.3)
PICKWICK	7512	8339(11.0)	10.4	10.7(2.9)
CHICKAMAUGA	4058	3103(-23.5)	5.7	4.4(-22.8)
WILSON	6739	7563(12.2)	7.7	8.7(13.0)
BANKHEAD	3847	4083(6.1)	3.6	3.9(8.3)
OLIVER	3879	4034(4.0)	3.5	3.9(11.4)
DEMOPOLIS	4053	4005(1.2)	3.5	3.9(11.4)
COFFEEVILLE	3785	3960(4.6)	3.5	3.9(11.4)

[a]This was the utilization experienced at Oliver in 1980 when average tow sizes of 3.9 barges per tow were observed.
[b]Based on 1976 FMS barge loadings per tow at IHNC.
[c]Percent error at Chickamauga appears excessively high due to low traffic volume. This error stems largely from tonnage discrepancies between FMS and WCSC data.

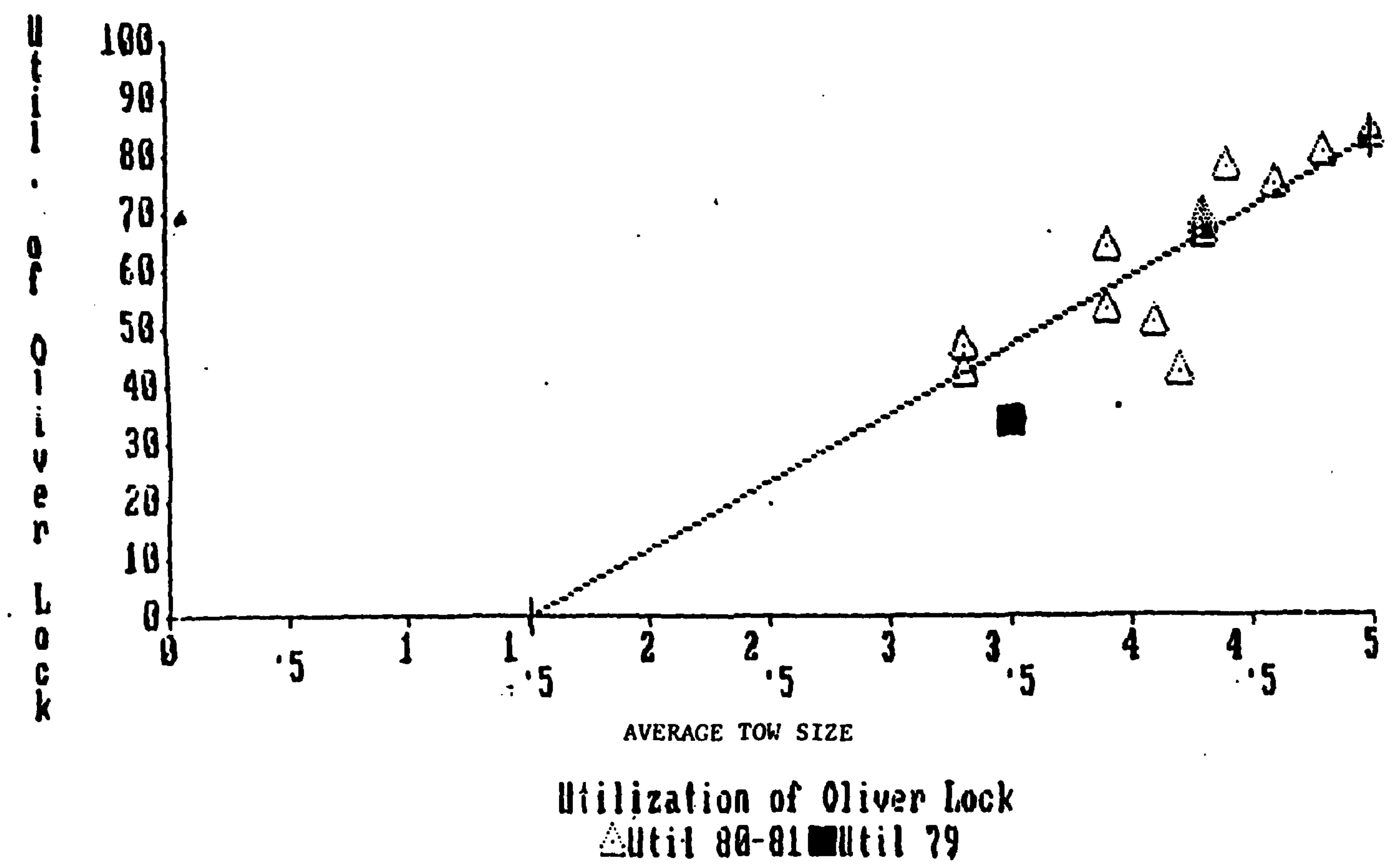

Figure B-III-1. Tow size versus utilization

1979. The 1979 data were also run for comparison purposes, with the nonstructural improvements at Oliver. With the mooring cells, industry self-help, ready-to-serve, and 1-up/1-down combination implemented, the utilization associated with a 3.9-barge tow size was 28 percent, a significant savings over the unimproved Oliver.

With Chickamauga, a small lock on the Upper Tennessee River, a relatively low volume of traffic (1.5 million tons in 1979 according to PMS data), proved to be difficult to calibrate. In terms of percentage, the simulation base year tonnage at Chickamauga was considerably below the tonnage levels observed at the lock and this caused all of the other parameters to be low. It appears that the major discrepancy is between the Waterborne Commerce data and PMS data for that year. Since the origin and destination of the missing traffic was unknown, no attempt was made to artificially boost the tonnage level at this lock. Because the tonnage level was low, TCM found it more efficient to use smaller tows for the movements. Various attempts were made to improve the agreement of the tow size data. It was discovered that changing the tow size at this lock also adversely affected the other Tennessee River lock tow sizes. Therefore the TCM results shown in Table B-III-1 were utilized for study purposes.

Another reason this error in calibration was tolerated was due to the significant impact anticipated at this lock by the TTW traffic. In 1990 the TTW is forecast to add approximately 6 million tons of traffic to this lock, which will comprise about 70 percent of the total traffic. This, in effect, changes all basic parameters causing the TCM to reoptimize based on TTW traffic characteristics. For example, the percent utilization jumps from the mid-20's in 1979 to 87 percent in 1990 as a result of the addition of TTW traffic. Assuming that the rate of growth for the missing traffic is the same as that for the remaining traffic (less TTW), differences in total tonnage in 1990 would be approximately 8.4 percent, an acceptable level.

The IHNC Lock was another lock that proved to be a problem in obtaining an acceptable level of calibration. Since 1979 data were not available, 1980 PMS data had to be used for comparison with 1979 WCSC traffic data. This was not a significant problem since the tonnage differential was within an

acceptable level (5.5 percent). In addition, the barges per tow were identical and the percent empty, percent utilization, and hours of delay were within an acceptable range. However, the tons per barge reflected by the TCM were considerably higher than that recorded by PMS (1859 versus 1521) leading to approximately 20 percent fewer barges and tows with the TCM. It was learned that the average loading per tow in 1980 had decreased from previous years, though the reason for this drop was not known. Further investigation revealed that the average loading per tow in 1976 (the year used for the IHNC replacement study) was considerably closer to the TCM value (1768 versus 1859, or a difference of 5.1 percent). LMVD considers that the 1976 PMS data are more reflective of the typical operations at the IHNC in a peak year. Using the 1768 tons per tow, the difference in the recomputed PMS number of tows and barges and those reflected by the TCM is 9 and 10 percent, respectively. This level of difference was determined to be acceptable for study purposes.

BASE YEAR COST DEVELOPMENT

Once the calibration was completed, the base year cost data base must be computed. This data base will be used to adjust rates in the future year analysis. The results from the TCM calibration run were processed by the Resource Requirements Program Postprocessor program (PPI). This computed the costs of operation under the modeled calibration conditions. These costs were then processed through the MEA program to associate the base rate data with the modeled cost data and the base year cost data file was saved. This file will be used with all future MEA runs to compute the adjusted rates and rate savings under future conditions.

FUTURE YEAR RUNS

The procedure followed for all future year modeling is described in this section. The traffic for the year being modeled is extracted from the shipment data base and the observed dedication factors are applied to each movement. This shipment list is then processed for the system with the Oliver Lock replaced and with improvements at the Demopolis and Coffeeville Locks.

The shipment list is processed by the TCM. A movement file for the WAM is then created, a WAM model run is made, the postprocessor program is then executed to generate the new estimated cost file (including combined operational time data from TCM and WAM), and the MEA program is executed to create the estimated rates and rate savings. A comparison is made between the TCM and WAM results at the locks to determine if the capacity of any locks was exceeded and if significant differences existed in the modeled lock utilization or delay and lockage times. If a lock capacity was exceeded, then the required tonnage is removed from the projected shipment file until an estimated capacity tonnage level at those locks is reached. The method described above is used to remove this tonnage. If a discrepancy is found between the TCM and the WAM results, an adjustment is made to the TCM capacity, processing times, or delay factor to allow for changing traffic characteristics. The process is repeated until all locks are within their capacity and the results from the TCM and WAM are compatible.

Then the shipment file for the future year is used to begin modeling the system without replacement of Oliver Lock and improved operating conditions at Demopolis and Coffeeville. The procedure described in the paragraph above is repeated until the tonnage through the Oliver Lock is within the capacity as determined by the WAM.

The MEA results from the with and without conditions are then compared to determine the benefits of the replacement of Oliver.

NONSTRUCTURAL IMPROVEMENTS

Because of the congestion problems expected to occur at Oliver Lock under without project conditions, the following nonstructural improvements were assumed to be in effect at the lock during the 50-year project life:

Mooring cells
Industry self-help
Ready-to-serve
1-up/1-down

These improvements were built into the estimated locking components times for modeling purposes rather than modeled explicitly.

In addition, due to congestion problems at other key locks on the system under both with and without project conditions, various combinations of non-structural improvements were tested and those which were found to have the greatest influence on increasing capacity were considered to be in place during the 50-year project life. These were:

Kentucky-Barkley
- Ready-to-serve
- 1-up/1-down
- 3-tow bias wait for Kentucky before utilizing Barkley

Coffeeville and Demopolis
- 1-up/1-down
- Improved approach and locking times

Inner Harbor Navigation Canal
- First-in/first-out (found to be comparable to 1-up/1-down)
- Multitow lockages

Chickamauga
- Ready-to-serve

It should be noted that a ready-to-serve policy is only appropriate at those locks experiencing multicut lockages. Such is not the case at the IHNC, Demopolis, or Coffeeville.

One structural change was introduced into the system for both with and without Oliver replacement modeling runs. Since an additional lock chamber is under construction at Pickwick Lock, the 1,000- by 110-ft lock chamber was considered to be in place for all future condition tests.

POTENTIAL CONSTRAINT PROBLEMS OTHER THAN LOCKS

Two potential constraint problems other than locks were addressed. These were the possibility of water shortage problems at Holt Lock and Dam and the 73 bends and bridges below Demopolis identified by the Corps and towing representatives as potential congestion points. These issues were addressed during the study effort and were subsequently dismissed when they were found not to be significant. However, the effects of the bends and bridges on overall transit times of traffic utilizing the BWT were included in the analysis. Results of the analyses performed on both the water shortage and bend congestion issues will be briefly discussed.

WATER SHORTAGE

The possibility of a water shortage at Holt Lock and Dam results from analysis of monthly flow duration curves. The lowest average monthly flow during the year has historically been experienced during the month of October. PMS data for the river indicated that over the 1976-1980 period about 8.8 percent of annual traffic passed through the lock during October. The projected increase of traffic on the river at Holt Lock was converted into the number of required emptyings of the lock during October and compared to the available water. It was concluded that at the initial year of the Oliver project, regulatory measures would have to be taken to allow uninterrupted flow of traffic during the month of October for approximately 10 percent of the time. It was further concluded that the measures such as water conservation and recirculation, pumpback from the downstream pool or upstream impoundments were not advisable at this time as they entailed large expenditures for maintaining about 1 percent of the annual traffic on the river. The concern about possible water shortages was dismissed at this time due to its insignificant impact on traffic.

BEND AND BRIDGE CONSTRAINTS

As discussed above, 73 bends and bridges on the lower BWT below Demopolis were identified as being potential congestion problems. These were modeled in the WAM and the congestion at each was monitored as traffic increased over the

50-year project life. It was found that not one of the bends realized a delay substantial enough to warrant improvements. Based on the results of this analysis, it was determined that the primary constraints on the waterway were the locks rather than the bends. For example, in year 2000, under with project conditions, the average delay at the most congested bend was only 0.14 hours. However, the effects of bends and bridges on overall transit speed of tows and the delays at these points were included in the economic analysis.

The following example presents the tonnage and major transportation classes diverted at key locks experiencing constraint problems for two key years during the project life under both with and without project conditions:

	(M Tons) Years				
	With Project		Without Project		Major Transportation Classes
Lock	1990	2010	1990	2010	
Kentucky/Barkley	0.4	9.3	0.7	9.3	1, 8, 10
IHNC	9.3	20.7	10.7	20.4	1, 2, 7, 8
Chickamauga	0.3	5.1	0.2	3.1	1, 8
Demopolis	1.5	16.9	8.4	30.1	1, 8
Oliver	0.1	0.8	7.3	16.6	1

SECTION IV

RESULTS

The systems analysis study demonstrated that the benefits resulting from the replacement of the Oliver Lock continue to be large even with the TTW traffic sharing the lower BWT. The system benefits are presented in Table B-IV-I. The system benefits reflect the difference between the cumulative rate savings at the point of zero marginal rate savings for the with and without project systems. In addition, the BWT benefits are also included in Table B-IV-I. This reflects savings to traffic using the BWT at some point in its movement but not including traffic that did not use the BWT. Finally, the last benefit figure reflects the rate savings and benefits for the traffic that passed through the Oliver Lock.

Table B-IV-1

Benefits

Oliver Lock Replacement Project

(Millions of Dollars)

	1990	2000	2010	2039
System benefits	$ 30.1	34.8	42.0	42.0
BWT benefits	29.1	32.4	44.2	44.2
Oliver benefits	30.7	35.3	50.8	50.8

It can be observed that generally the overall benefits to the waterway begin at about $30.1 million and continue to grow to $42.0 million in the year 2010. It is also noted that the benefits to the Oliver and BWT traffic grow at a more rapid rate with the benefits to Oliver traffic being $50.8 million in 2010. However, the benefits to the total system traffic are much lower indicating that while the Oliver traffic realizes substantial benefits, other traffic has much smaller rate savings. It should be noted that for purposes of this analysis traffic projections were leveled off in 2010 and held constant for the remainder of project life. It is recognized that as a projection is extended further out in time, the credibility is increasingly weakened. Many agencies, such as the Bureau of Mines and Department of Energy,

limit their projections to 20-25 years in the future. Sensitivity requirements in ER 1105-2-40 dated 8 January 1982 also acknowledge the unreliability of distant year projections. Therefore projections and benefits are limited to the first 20 years of project life.

Benefits for the total system were used to compute the project benefits (the first set of columns in Table B-IV-1). Based on these benefits, the average annual equivalent project benefits, computed at a 7-7/8 percent interest rate, total $35,700,000. As discussed in the main body of the report this results in a benefit-to-cost ratio of 3.5.

Another important result of the analysis is the identification of locks in the system that cannot process all of the projected traffic (see Table B-IV-2). It was found that the IHNC Lock could not pass the projected traffic in even the first future year, 1990. Its capacity was found to be about 27 million tons. Changing capacities for locks were evident in most cases and appeared to be a result of changing backhaul characteristics and fleeting changes from the TCM. Kentucky/Barkley and Chickamauga Locks were found to reach capacity early in the simulated future. This included full utilization of the Barkley Lock, something that industry is not doing at the present time.

The locks with the most influence on constraining TTW traffic are Kentucky Lock on the Tennessee River and Barkley (a parallel lock) on the Cumberland River.

Kentucky-Barkley capacity was found to be constrained at approximately the 90 million ton level primarily because of the constraint problems of the Lower Cumberland River. The towing industry has been reluctant to use the waterway due to the severe current and bend problems. A 6-barge tow is currently considered to be the largest tow size that can use this portion of the Cumberland. As a result, the 110- by 800-ft chamber at Barkley is vastly underutilized. Another factor affecting the capacity at Kentucky is the heavy use of 15-barge tows forcing double lockages at the 110- by 600-ft chamber.

The capacity levels determined by the WAM (which included nonstructural improvements) are in agreement with findings of lock capacity studies performed by ORD.

Table B-IV-2

SYSTEM TONNAGES*

	WITHOUT PROJECT					WITH PROJECT				
	1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
L&D 53	96.6(35)**	111.2(22)	125.8(46)	125.8(46)	125.8(46)	96.8(35)	110.5(20)	125.9(44)	125.9(44)	125.9(44)
L&D 52	116.5(51)	133.8(61)	151.8(68)	151.8(68)	151.8(68)	116.4(51)	133.1(57)	151.8(60)	151.8(60)	151.8(60)
SMITHLAND	128.1(75)	148.1(85)	166.1(89)	166.1(89)	166.1(89)	127.9(75)	147.9(83)	165.8(90)	165.8(90)	165.8(90)
THNC	24.5(93)	26.5(95)	26.6(94)	28.6(94)	28.6(94)	25.9(96)	26.3(89)	28.3(93)	28.3(93)	28.3(93)
KENT/BARK	69.2(80)	81.0(91)	85.5(94)	85.5(94)	85.5(94)	69.5(80)	80.1(90)	85.4(95)	85.4(95)	85.4(95)
PICKWICK	38.7(29)	45.4(39)	48.4(40)	48.4(40)	48.4(40)	38.8(29)	44.4(39)	48.5(40)	46.5(40)	48.5(40)
CHICKAMAUGA	7.7(74)	9.2(82)	8.4(82)	8.4(82)	8.4(82)	7.6(77)	8.8(96)	6.5(64)	6.5(64)	6.5(64)
WILSON	27.5(83)	32.2(47)	28.5(58)	28.5(58)	28.5(58)	27.5(84)	31.1(44)	26.8(68)	26.8(68)	26.8(68)
BANKHEAD	17.2(26)	16.6(25)	12.4(18)	12.4(18)	12.4(18)	19.1(31)	21.5(35)	27.2(45)	27.2(45)	27.2(45)
HOLT	18.2(34)	17.8(32)	20.1(34)	20.1(34)	20.1(34)	24.9(54)	28.4(55)	35.8(77)	35.8(77)	35.8(77)
OLIVER	18.3(96)	18.2(97)	20.6(99)	20.6(99)	20.6(99)	25.5(51)	28.8(53)	36.4(78)	36.4(78)	36.4(78
WARRIOR	18.5(33)	18.5(29)	20.7(32)	20.7(32)	20.7(32)	25.7(47)	29.1(48)	36.4(68)	36.4(68)	36.4(66)
DEMOPOLIS	42.7(75)	49.5(84)	43.9(76)	43.9(76)	43.9(76)	49.6(88)	56.8(96)	57.1(95)	57.1(95)	57.1(95)
COFFEEVILLE	43.2(73)	50.2(81)	44.2(71)	44.2(71)	44.2(71)	50.1(84)	57.5(91)	57.5(89)	57.5(89)	57.5(89)
GAINESVILLE	29.5(53)	37.6(74)	30.9(60)	30.9(60)	30.9(60)	29.6(53)	34.4(69)	26.6(52)	28.6(52)	26.6(52)
BAY SPRINGS	28.9(47)	35.3(57)	28.7(45)	28.7(45)	26.7(45)	28.9(44)	33.2(56)	26.5(41)	26.5(41)	26.5(41)

* Tonnages are in ktons.
** Values in ( ) are the percent utilization of the available lockage time.

Of particular importance to this study were several other capacity values. The present Oliver Lock was found to be at capacity in the first decade, 1990. While the capacity grew, probably due to the factor mentioned above, from about 18 million to about 21 million tons, it did not match the capacity of the other locks in the BWT through which most of the traffic must pass. Also, the capacities of the Demopolis and Coffeeville Locks were not exceeded even with the replacement of Oliver. This apparently was due to the limitations as IHNC, Kentucky/Barkley, and Chickamauga Locks. Finally, the constrained bends on the lower BWT that were of initial concern proved not to be a serious constraint. Delays from these bends were an order of magnitude smaller than those caused by the locks. One of the reasons is probably due to the traffic control function provided by the Coffeeville and Demopolis Locks.

SECTION V

REQUIRED SENSITIVITIES

ER 1105-2-40 dated 8 January 1982 requires that certain sensitivity analyses be performed as a test of the project's feasibility. These include halting traffic growth at 20 years, assessing the impact of user fees to recapture systemwide O&M costs, assessing the impact of a capital cost recovery fee for the project under study, and consideration of the relative feasibility of a congestion fee alternative. Each of these analyses is discussed in turn in the following paragraphs.

TWENTY-YEAR BENEFITS

For purposes of this analysis, forecasted traffic and benefits were leveled off at the 20-year (2010) level and held constant. The resulting average annual benefits total $35,700,000 yielding a benefit/cost ratio of 3.5 to 1.

USER FEES

The Administration has proposed legislation (S.1554) to recapture 70 percent of the annual operations and maintenance costs associated with maintaining the inland waterway system. If implemented, it would result in an assessment of 1.1 mills per ton-mile beginning in October 1984. Since this cost represents a transfer of costs from one sector of the economy to another, it does not affect the NED benefits. However, since it does represent an increase in operating costs to the individual towing companies it affects the marginal movements, thus resulting in diversion of some movements which otherwise would have continued using the waterway system.

This analysis was accomplished following guidance provided in draft EC 1105-2-123. Benefits were grown at a rate of 4.5 percent per year to reflect inflation. The 1.1 mill per ton-mile systemwide O&M fee specified in S.1554 is also grown at 4.5 percent, less 2.5 percent estimated annual system traffic growth, or 2 percent net.

As shown in Table B-V-1 below, the analysis shows no significant impact on traffic through imposition of the systemwide O&M fee. Even without adjustments for inflation, the amount of diverted traffic is small compared to the total system tonnage.

Table B-V-1

User Fee Impact Analysis

Year	Total ktons	Total kton-miles	Diverted ktons Without Inflation	Diverted ktons With Inflation	Decrease in kton-miles Without Inflation	Decrease in kton-miles With Inflation
1990	242,973	173,447,253	11,257	10,735	9,367,443	8,685,522
2000	275,362	193,050,654	15,155	8,038	12,596,237	5,240,779
2010	305,600	215,926,995	11,526	5,257	10,929,250	3,601,143
2020	305,600	215,926,995	11,526	4,936	10,929,250	3,288,489
2030	305,600	215,926,995	11,526	3,257	10,929,250	1,598,286
2039	305,600	215,926,995	11,526	1,395	10,929,250	1,062,632

COST RECOVERY FEE

In S.1554, the Administration has also proposed that 70 percent of the average annual capital cost of the project be recaptured through a user charge. As in the case of the user fee to recover 70 percent of annual O&M charges, the capital recovery fee does not represent a decrease in NED benefits but, rather, a transfer of cost from one sector of the economy to another.

The methodology prescribed in draft EC 1105-2-123 was used to perform this analysis. The impact on traffic was analyzed both with and without adjustments for inflation. This fee represents an addition to the O&M recovery fee and is applied to the rate savings remaining after application of the O&M recovery fee to the Oliver traffic that was not diverted in the above analysis. As shown in Table B-V-2 below, the impact of the segment specific lock replacement cost under both conditions is insignificant. Therefore the project is viable throughout the 50-year project life.

Table B-V-2

Cost Recovery Fee Impact Analysis

Year	Total ktons	Total kton-miles	Diverted ktons Without Inflation	Diverted ktons With Inflation	Decrease in kton-miles Without Inflation	Decrease in kton-miles With Inflation
1990	25,479	10,212,596	38	18	24,094	11,034
2000	28,828	11,104,567	47	23	29,771	14,099
2010	36,393	14,380,813	0	0	0	0
2020	36,393	14,380,813	0	0	0	0
2030	36,393	14,380,813	0	0	0	0
2039	36,393	14,380,813	0	0	0	0

CONGESTION FEE ANALYSIS

System benefits presented below reflect the equilibrium traffic level (average rate savings (ARS) = average towing costs (ATC)). At this level, the marginal shipper would be indifferent as to his choice of mode, since the waterway shipping costs and costs via an overland mode are equal. The marginal shipper pays his average towing costs at equilibrium; however, his true marginal cost is considerably higher. The optimum level of traffic (also known as the "social optimum") would be realized by restricting system traffic to the level where the rate savings of the marginal user just equals his marginal towing cost (MTC) (ARS = MTC). Lock congestion fees and other similar nonstructural traffic rationing (demand management) have been proposed as a means of attaining the socially optimum traffic level on a congested waterway.

The rate savings and barge shipping costs for each prospective movement are a function of the total system routing. Therefore determination of the optimum traffic level requires a knowledge of the ARS and average system towing costs for all traffic that would transit Oliver Lock at the equilibrium system traffic level as well as the marginal system towing cost for each Oliver movement. At the equilibrium traffic level, the MEA program also provides a listing of all system movements ranked from highest to lowest unit rate savings as well as the total system rate savings.

The rate savings for each movement (and for the system total) for any

given year have been adjusted to include the average barge linehaul costs on the system reflected by WAM. Therefore average system towing costs require no further consideration. In order to determine the existence of marginally inefficient movements (MTC > ARS) at Oliver at the system equilibrium level, additional increments of Oliver traffic were simply diverted (in order of willingness-to-pay) beginning at the equilibrium ranking. For each additional increment of diverted traffic, the entire system modeling process was repeated. Output from the iterative runs was then used to identify incremental changes in the total system rate savings and the portion of total system savings attributable to Oliver traffic.

Where diverted Oliver traffic movements (at the system equilibrium level) exhibited MTC in excess of rate savings, the diversion process would result in system rate savings. Conversely, diversion beyond the social optimum would result in a decline in total system rate savings. Through this iterative process, the social optimum traffic level was determined for Oliver Lock. The total system rate savings with Oliver traffic restricted to the social optimum were then compared to the total system rate savings at the equilibrium level to determine the incremental benefits for a congestion fee at Oliver. The amount of the congestion fee to be imposed at Oliver is determined by computing the difference in the ARS of Oliver traffic at equilibrium versus the social optimum system traffic levels.

The resulting benefits are shown below for various years during the project life.

Year	System Benefits
1990	7,783,000
2010	11,253,000
2039	11,253,000

The gross average annual system benefits from imposition of a congestion fee total 9,462,000, considerably less than the benefits realized from lock replacement. It should be noted that this analysis erroneously assumes zero costs of imposition and maintenance of this fee.

ATTACHMENT 1

SYSTEMS ANALYSIS

In the past, the planning, design, and maintenance of the Nation's waterways have been performed on an individual basis, generally in isolation of other related functions and without regard to their effects on other parts of the total navigation system involved. However, current conditions make it quite clear that in this time of limited funds and stringent national priorities, a systems analysis of waterways is desired and required. A need also exists, particularly with today's advanced technology, to experiment with non-structural improvements including traffic control and regulation to improve present operations and to better plan and program major construction. The interrelationships between the various components of a waterway system are so complex and the data requirements to develop such interrelationships are so voluminous that any approach to a complete systems analysis must necessarily be computer-oriented.

To meet these needs, the COE, with the aid of various private economic and systems analysis consultants, has developed several transportation, economic and statistical models and techniques which are useful in the analysis of a complex nationwide or regional transportation system. In general, these techniques have been designed to help COE planners achieve two goals:

1. To operate and maintain the inland waterway network as effectively and efficiently as possible.
2. To select the best size, location, and timing of inland waterway improvements.

It should be understood that the use and knowledge of these systems analysis techniques are accelerating, and that many of the models and other analytical "tools" now available are still in developmental stages. Application of a particular model to any given study effort generally requires custom "tailoring" of the model or its data base to best fit the given study purposes and available data, and to allow for timely and cost-effective model execution.

SYSTEM DESCRIPTION

NATURE OF THE SYSTEM

The Oliver Lock and Dam is a part of the Black Warrior-Tombigbee (BWT) Waterway system and is located at mile 346 on the Black Warrior River within the city limits of Tuscaloosa, Alabama. The lock is the smallest lock on the system with dimensions of 460 by 95 ft, compared to 600 by 110 ft for all the other locks on the BWT. The BWT is primarily a local system with most of the traffic moving between points on the BWT to or from Mobile and other points on the East GIWW. However, when the TTW begins operation, most of the traffic using the TTW will be sharing the lower Tombigbee River with the BWT traffic. Much of the TTW traffic will pass through locks on the Tennessee and Ohio Rivers and other tributaries of the Ohio. The TTW will provide an alternate waterway route to the Lower Mississippi River, thus potentially influencing the Lower Ohio River below the junction with the Tennessee River. There is some interchange of traffic between ports in or near New Orleans and the East GIWW that passes through the Inner Harbor Navigation Canal (IHNC) Lock.

Therefore, for purposes of this study, the "system" was defined based on a determination of which segments of the inland waterway system could potentially be impacted to any significant degree by the project. Preliminary analysis of the commodity movements affecting the Oliver Lock and Dam and other portions of the waterway system over which Oliver traffic moves narrowed the principal components of the system to the following waterways: BWT, TTW, Tennessee, Lower Ohio, Lower Mississippi and the East GIWW. All other segments of the Mississippi River-Gulf Coast inland waterway system were found to be extraneous to the purpose of this study and, therefore, were included at a much lower level of detail in the study. It was found through further analysis that the major impacts of the proposed improvement would be limited to the BWT Waterway, particularly Coffeeville and Demopolis Locks. However, as the Oliver Lock replacement was found to have some degree of impact on the marginal system benefits, the remainder of the system was included in the analysis. The system definition used in this study is presented in Figure B-II-1 which displays the significant waterways and port definitions. All major locks on these principal waterways are included.

CHARACTERISTICS OF WATERWAY SERVICE

Waterway service is provided on the BWT by five primary carriers. While this indicates that competition might be limited, this is not the case. In the last several years, new operators have begun to move on the BWT and have influenced the manner in which the carriers function. Some of these carriers began operations on the BWT in anticipation of the opening of the TTW; it is anticipated that many other carriers will begin operations as the time for opening the TTW is approached. Throughout the entire inland system, over 2,000 carriers are engaged in waterway transportation service. In size, they range from owner-operators of a single towboat to managers of very large fleets of both towboats and barges. In recent years, financial institutions have developed investment plans whereby individuals can purchase shares in a single barge. The competitive nature of the towing industry is exemplified by the concern which most firms express regarding the quotation of barge rates. In the view of most operators, wide dissemination of contract rates on barge service would seriously jeopardize their respective competitive positions.

The characteristics of waterway service vary from operator to operator, depending upon the contractural arrangements under which carriage is performed. Many shipments are performed under contracts which are designed to minimize turnaround time for movements in a single direction. Under these conditions, backhaul movements appear to be discouraged because of the time required in each delivery cycle by the operator to line up a backhaul movement, for additional time loading and unloading of the backhaul shipment, and if required, barge cleaning activities. Equipment used in this type of service is generally dedicated to a specific directional movement between a specified pair of origins and destinations. This kind of dedication is most generally applicable to coal shipments. Backhaul movements also have been discouraged for this type of dedication from an institutional point of view, where the waterway equipment is owned and operated by a holding company for shipment of its own commerce, generally coal for electric generating plants.

Another type of dedication observed on the inland waterways is often applicable to chemical and petroleum products. This involves the multidirectional movement of commodities among various origins and destinations, where

production, consumption (or overland distribution), and waterway shipment are accomplished within a single managerial organization. This type of dedication arrangement allows for backhaul shipments where the compatibility of barge types exists and where the potential for reverse-direction shipments is available within the corporate structure. However, because of the differences in the characteristics of the various chemical and petroleum products, special barge cleaning efforts are often required, and backhauls are again often discouraged.

Thus backhaul potentials in the inland waterways tend to be limited by the commodity flow potential and associated equipment requirements. Petroleum products moving from Gulf coast refineries into the BWT basin use barge equipment for which there exist few compatible commodity flows in the reverse direction. Crude petroleum is moved from the BWT basin to these refineries; however, this product cannot be mixed with the refined petroleum products and frequently does not use the same equipment. Shippers of coal downbound to major coal consumers and for export at the lower BWT, Mobile, and Gulf coast area can in some cases find suitable backhaul movements with metallic ores being shipped to the Birmingham area; but this potential is limited to the amount of each product being shipped. Some chemical products require specially designed barges which limit or eliminate the potential for use in shipping other chemical products. Generally speaking, the longer the waterway haul distance, the more inclined the operator is to search for backhauls. This is simply due to the fact that for longer transit times, the proportion of total cycle time required for barge cleaning, backhaul loading, and backhaul unloading is smaller than for short hauls and with a long waterfront there is a larger potential for locating backhaul movements. Many of the movements on the BWT are local to the system and therefore the opportunities for backhaul are limited and the percent of time for backhaul turnaround is large compared to the linehaul time. The introduction of large coal and grain movements when the TTW opens will probably increase the percent of empties due to the lack of backhaul potential.

Most waterway towing companies have well-organized dispatching systems. Operational headquarters are constantly aware of the location and condition of every towboat and barge in their fleets, as well as any equipment obtained on

a contract, lease, or rental basis. As explained by one towing company, each towboat contacts its headquarters on a scheduled basis throughout the day. Towboat captains are advised of towing conditions along the route, and changes to towboat operating procedures, changes in routing plans, and revisions to barge pickup and drop-off orders.

Each waterway operator employs methods and procedures for optimizing equipment utilization which are tailored to the particular geographic area of operation, contractor requirements, and other factors affecting the services provided. Differences in management philosophy, preferences in technology, and scale of operation are reflected in operating plans. One carrier may plan his operations around the use of small- or medium-size towboats assigned to the same tows from points of origin to destination. A second carrier may develop his operation to use larger towboats from origin to destination. Still another operator may assign towboats of different sizes to different reaches of the waterway system; depending upon the origin and destination characteristics of a shipment, it may be handled by two or more towboats during the routing. Obviously, this latter type of operation requires a rather large scale of operation not commonly found on the BWT, but is often preferred where traffic volumes permit and where large differences in tow sizes can be achieved, e.g., along a GIWW-Lower Mississippi-Ohio River route. Most movements on the BWT are performed with one size towboat, primarily 1,800-2,000 hp. When the TTW is opened it is expected that the tows will be refleeted above Demopolis Lock and Dam and will probably involve an exchange of towboats.

WATERWAY SERVICE COST COMPONENTS

To some extent, the waterway transport industry is akin to the motor carrier industry. Like the highway system, the waterway system is available to whomever wishes to use it. Institutional and physical impediments affecting entry to and exit from the industry have generally been negligible. Consumers of waterway service may supply their own equipment and historically have done so. As stated previously, production units (firms) are sometines small in size. Within certain bounds, economic limitations to capacity expansion within a production unit are not great because such expansions can occur in small units by purchase of additional towboats, barges, and waterside facilities.

In certain other respects, the towing industry departs from the characteristics of motor carriage and takes on traits of the rail industry. While it is obvious that the costs of the waterway system over which the industry operates remain largely outside of the towing industry cost structure, it is important to note that waterway towing equipment is not nearly as sensitive to obsolescence and depreciation as is motor carrier equipment. Even with the tremendous expansion in the fleet required to accommodate the 60 percent increase in traffic since 1960, the existing equipment is somewhat aged. For example, towboats currently in use on the inland waterway system have an average age of about 19 years. The age of the 2,300 standard open-hopper barges in use on the system averages 20 years. Some of the equipment dates to the early 1930's. Barge equipment in use on the Great Lakes and east and west coasts is even older.

Stated very simply, the short-term fixed cost of waterway service per unit of output is functionally determined by the following factors:

- value of towing equipment used
- physical capacity of equipment used
- proportion of equipment capacity used
- physical constraints of the waterway system
- institutional constraints on waterway service
- probability of accident or loss
- management and supervision requirements
- interest on investment
- the fronthaul-backhaul relationship

Variable costs of waterway service per unit of output is functionally related to:

- value of labor
- value of fuel
- value of supplies
- time equipment is in use
- schedule of maintenance and repairs
- proportion of equipment capacity in use
- probability of accident or loss
- institutional constraints on waterway service

When actual capital outlays are used in these relationships, the resultant costs are financial in nature. When opportunity costs are used in lieu of capital outlays, the result becomes economic costs.

It is difficult to make broad generalizations about the cost structure of the industry that are meaningful. Each movement must be considered independently. The operational pattern for each waterway operator is developed in a manner which takes into consideration an array of factors that influence the production function for that particular firm. The resultant unit costs are highly variable from one movement to another. Competition inherent within the industry, an imbalance in the directional characteristics of traffic demands, and differences in towing conditions throughout the system make such variations a natural characterization of the industry.

SENSITIVITY OF COST TO AGGREGATE SYSTEM TRAFFIC LEVELS

Waterway's user costs are also related to overall system traffic levels. This can be illustrated by way of an example:

Consider a commodity movement from point A downbound to point B. Downbound transit time is initially 80 hours and upbound time is 100 hours.

The example movement must share use of the system with other waterway movements. A high aggregate level of traffic over this reach can cause congestion, particularly if the reach encompasses one or more lock and dam structures, which would affect the transit time of the movement. Suppose that the waterway between point A and point B contained six lock and dam structures each with average lockage times of 1 hour. Then, about 7.5 percent of downbound transit time between A and B is required for lockages and 6 percent of upbound time is for lockages. If overall traffic growth throughout the reach increases average time required for each lockage to 2 hours because of queues at each lock, then transit time from A to B increases by 7.5 percent and transit time from B to A increases by 6 percent. If only one of the six structures has less capability than the others, such that lockage and queue times grow to 30 hours while the others remain at 2 hours each, then the total transit times would increase by 44 and 35 percent for A to B and B to A, respectively.

Obviously, the increases in transit times translate to increased user costs. For each shipment cycle, not only are personnel and equipment tied up for longer periods of time, but additional crews and equipment purchases may be required to move a given annual volume of traffic.

Another aspect of the relationship between aggregate traffic levels and costs for individual waterway movements entails the variability of origin-destination characteristics. The origin-destination addressed in the example originally had transit time of 80 hours downbound and 100 hours upbound. Suppose, however, that the movement in question had a much longer haul, involving 400 hours downbound and 600 hours upbound. For such a movement, a 35-hour increase in transit time in either direction would have a much smaller impact on total shipping cost than for the shorter movement.

All other things being equal, continued increases in queue times at a constricted lock would eventually force movements for which costs are most severely impacted to seek alternative routings or modes of transport. Those movements with costs less severely affected would continue the water routing with greater capital investment and marginally higher unit costs.

SENSITIVITY OF COSTS TO SYSTEM CHANGES

It should be clear from the above example that any change made to the physical system which results in a reduction in transit time favorably impacts upon waterway service costs. By reducing total time in a shipment cycle, it also reduces the total investment in equipment required to provide the same level of service. If the system change entails improvements at a single lock and dam component of the system, then the relative impacts differ from one movement to another, depending upon the origin-destination characteristics and total haul distance. Short-haul movements which are most sensitive to localized delays at a single component of the system are obviously most sensitive to improvements made to alleviate congestion at that structure.

NONWATERWAY COSTS

To this point, only those costs associated with waterway shipment have

been discussed. More important to the consignee is the delivered price of the commodity being shipped. In addition to the costs of waterway service, other costs associated with transportation affect delivered price. These include costs for overland shipment to or from the waterway, loading, unloading, transloading, and any other assessorial charges required to complete the routing. The importance of these costs and charges is reflected in the fact that over 90 percent of all waterway movements on the BWT have off-river origins, destinations, or both. For some commodities, this proportion is much higher. About 90 percent of all coal movements are intermodal, and obviously all grain shipments originate off-river. Most petroleum fuel shipments are ultimately destined for the service station.

The effect of nonwaterway costs is to reduce the sensitivity of the final delivered price of a commodity to any changes in waterway service costs. The extent to which this occurs depends upon at least two factors:

- the relationship between delivered price and waterway service costs
- the relationship between total transportation costs and waterway service costs

ATTACHMENT 2

ECONOMIC MODEL CONCEPTION

ECONOMIC CHARACTERISTICS

The waterway system is compromised of a series of navigable natural rivers and pools with a draft and width fixed by law. The pools are often maintained by lock and dam structures having fixed lock sizes and service times. The physical specifications of the system dictate to a large extent the maximum physical product of the system. In most cases, the total system physical product is constrained more by the lock components than by pool and channel configurations.

The production function for the system actually entails a host of individual functions representing the specific commodity and origin-destination demands placed upon the system. Each has its own cost curve depending upon the number and location of components of the system used and the extent to which they are used. Some movements require more lockage time than others simply because of tow configuration and/or size.

Waterway industry physical output can be defined in a number of ways. Units of equipment moved on the system is a convenient measure of system and project operating efficiency. However, equipment movement does not always correspond to the direct delivery of cargo. Tons of cargo delivered is a more meaningful measure of output and would be suitable for systems analysis purposes, were it not for the fact that cargo movements travel over different distances and segments of the system in response to unique components of the demand schedule. The unit of output which captures distance as well as tonnage is the ton-mile. Differences in output corresponding to the various equipment usage, segment usage, and travel times are directly reduced to cost and benefit differences. Consequently, the "ton-mile" is selected as the most appropriate unit for universal measurement of system output.

The objective of systems analysis is to minimize time per unit of output, where ton-miles are used to measure output. The functional relationship

between time and output has its origin in queuing theory since locks tend to pose a first constraint to output. Figure 2-1 presents the general form of this curve for a single structure. For a given aggregate demand component, say for all tonnage between points A and B, the relationship between time and output could be constructed by adding such curves vertically for each structure located between A and B, and by adding curves representing pool constraints between A and B. The result would be a composite time-output relationship for that specific demand. Some of these same curves would also enter into the composite relationships for other demands as well (say from point A to point B).

The system has been constructed, is maintained, and is operated by the Federal Government. Since shippers do not pay all of the system costs, an externality results which tends to produce a long-run equilibrium traffic level which exceeds the optimum. The magnitude of the externality and the divergence between equilibrium and optimum levels is a direct function of system output in relation to system capacity. Shippers pay only their average costs for system use, not their true marginal costs. Consequently, in the long-run, shippers will choose the level of output which equates average system towing costs and demand, not marginal system costs and demand.

The standard textbook approach to the problem of waterway systems economic analysis involves application of supply-demand analysis and optimization techniques. A single private firm would attempt to maximize profits by attempting to operate at the point of intersection of marginal costs with marginal revenues. Since the objective of public investment is to maximize social welfare, two production levels are of importance. Optimum production would occur at the intersection of the marginal cost curve with the average revenue, or demand curve. However, in the long run (in the absence of institutional restraints) equilibrium production would occur at a level of output which exceeds the optimum.

Proper definition of costs poses another series of options. Benefits (cost-savings) for waterway transportation arise through the interaction of overland carriers, waterway carriers, terminal operators, shippers, and Federal waterway system maintenance and operation. However, only those costs

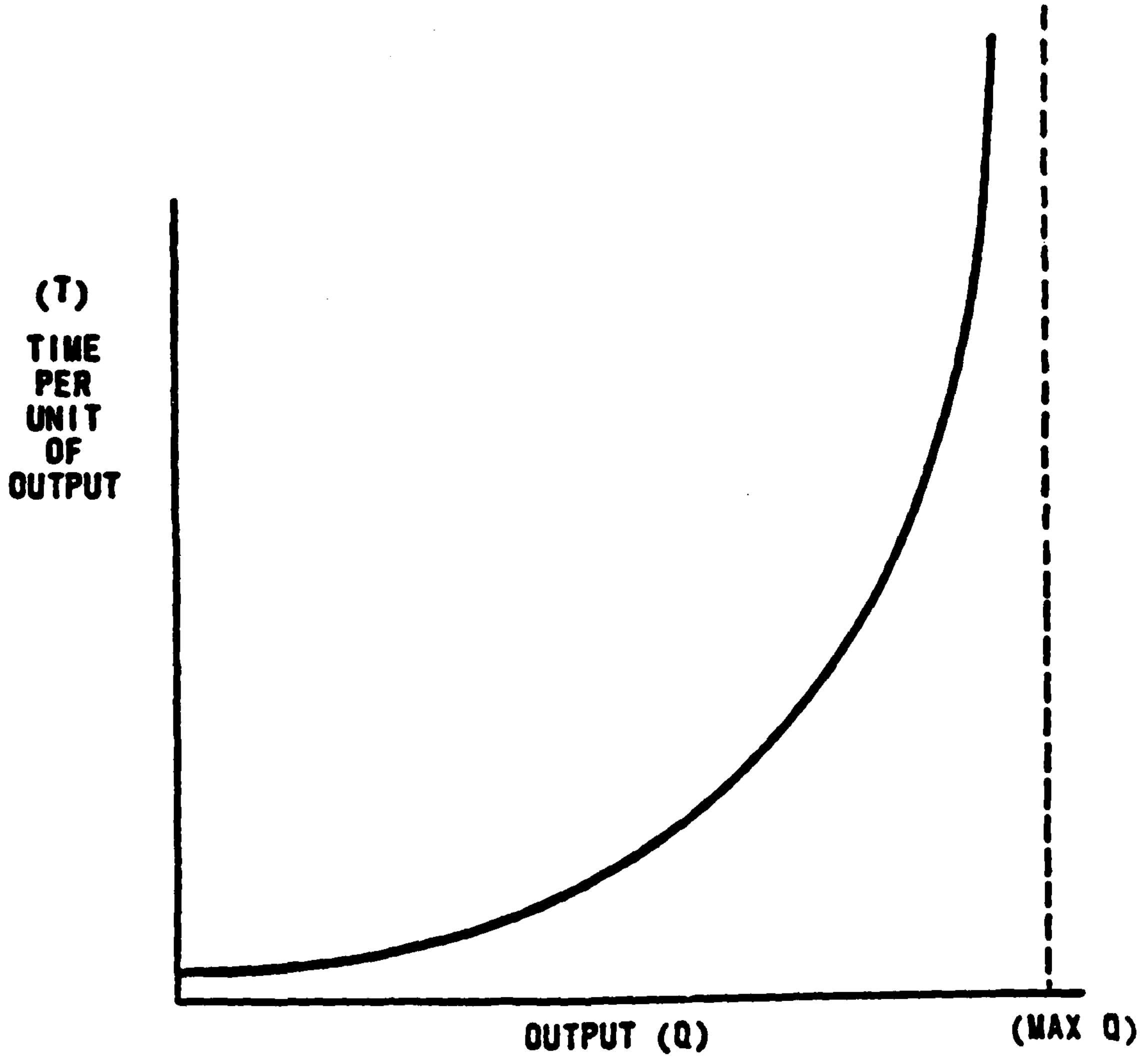

Figure 2-1. Lock service time versus lock throughput

which are deterministic to waterway traffic levels should be included in the model analysis. These would include costs for all activities within the waterway operator's production function as well as assessorial charges and costs for overland linkages. These are the costs which eventually must be borne by the shipper, who makes the decisions regarding transportation demands. Federal costs for system maintenance and operation are included only to the extent that they are internalized in the waterway operator's production function.

Definition of system benefits poses no problem. The benefit is the waterway economic advantage over the least-cost alternative routing. This economic advantage is denoted as rate savings, but also accounts for any differences in charges incurred for traffic arising from loading, unloading, and other activities not water-related. It is the total savings to the nation per unit of output for providing and maintaining the waterway system.

System definition presents another array of possibilities. The interrelationships between two or three locks and dam projects within a system can be easily identified. However, a large system containing many individual projects becomes much more complicated. Actions taken at one project can theoretically affect a project hundreds of miles away, even if there exists no common traffic. This relationship occurs because each of the projects may have separate traffic components which are both common to a third structure somewhere in the system. In actuality, the conditions under which such an effect could occur are rather restrictive, and for purposes of this study, projects in the system having traffic common to the BWT are of much more concern.

The demand schedule is a downward sloping schedule of aggregate waterway traffic demands. It should be noted that the traffic demands are bounded by some maximum output level for the system because of project constraints. Second, the waterway towing industry is not bound by the principles of welfare economics, but is compromised of a number of individual firms, each attempting to maximize profits individually. Third, the consumers of waterway transportation services are also attempting to maximize profits. Consequently, it is likely that actual traffic levels (output) will differ from the social

optimum. Over time, the questions to be answered by the model for each configuration of the system are:

- a. What volume of traffic will shippers and carriers choose to move on the waterway system, given each shipper's own unique set of economic and noneconomic variables?
- b. Given this same set of variables, what volumes of traffic will these shippers divert to alternative modes, ship to other destinations, or move over other routes?
- c. What are the origin, destination, and commodity characteristics of the traffic diverted, rerouted, or shifted by the shippers, given the same set of economic and noneconomic variables?
- d. What are the national transportation cost savings (or dissavings) associated with the decisions above?
- e. For the optimum level of traffic on the waterway, what volumes of traffic would be diverted to alternative modes of transport, shifted to new origins and destinations, or rerouted on the waterway?
- f. What are the origin, destination, and commodity characteristics of the tonnages diverted, rerouted, or shifted, given optimum waterway traffic levels?
- g. For the optimum waterway traffic levels, what are the transportation cost savings (or dissavings) to the nation?

To answer these questions, one must analyze the effect a system change has on each and every potential commodity movement. For each potential movement, the transportation charge is determined for a given system configuration and loading. The charges are compared with charges for the least-cost alternative routing, and system rate savings (or dissavings) are computed. The movements are then ranked from highest to lowest rate savings. For this ranking, accumulated system traffic, accumulated system rate savings, and accumulated shipping cost are tabulated as running totals to correspond with each potential movement. Marginal costs can be computed by dividing incremental differences in accumulated waterway routing transport charges by incremental differences in accumulated traffic.

Four system production levels are important. For either practical or theoretical reasons, these levels of production are equally important. First is the production level at which maximum net system rate savings are attained (MTC and ARS). This is the point of social optimum waterway use.

The second level is the long-run equilibrium level of traffic which would result in the absence of any institutional restrictions. At this level there are traffic movements which exhibit marginal towing costs in excess of average rate savings. However, since each shipper pays only the ATC, these "marginal" movements would continue to use the waterway system. This is the level used for benefit measurement on Oliver Lock.

The third level reflects a level of traffic beyond the equilibrium level. At this level there are traffic movements which exhibit negative average rate savings (ATC-ARS). This point of system production is significant since it is observed that traffic having such characteristics actually occurs on the waterway.

The reason for existence of negative-savings waterway movements include:

- Imperfect knowledge by shippers of available transportation options
- Market prerequisites and inertia, including the effects of long-term coal-transport agreements
- Firms just entering or leaving the market, or in the process of shifting between transportation modes
- Emergency shipments
- Provisions for future flexibility in transport modes, as in the electrical industry, to assure production certainty
- Overland transport equipment shortages
- Potential problems in WCSC commodity classifications
- Imperfect rate analysis for oversized shipments
- Failures in overland rate negotiations

The remaining production level is included primarily for reference. This level represents the output level corresponding to maximum system capacity.

Because of the nature of the cost curve, this production level would likely never occur over a sustained period of time if it is known that system capacity would never change.

Ordinarily, the remaining task would simply involve selection of the optimization criteria, determination of the proper intersects, and identification of the output aggregates on either side of the intersects. However, the nature of the waterway system is such that individual increments of output influence the costs of other output increments. Therefore each of the critical points must be determined through incremental diversions of traffic from the waterway and reiteration of the entire modeling process. The diversion analysis will be discussed later.

For each iteration, i.e., each traffic level, the model should output the total net system rate savings. This traffic level and associated benefits represent the results of evaluation of one point in time and one system definition. By varying the time and system definition independently and repeating the analysis, the ability of any system definition to accommodate projected traffic demands can be determined. Incremental differences between aggregate traffic levels and corresponding system benefits over time are attributable to the changes in system configuration. If the change in system definition involves only a single lock and dam structure, then the incremental differences are assignable to changes at the single structure.

Application of this conceptual model involves three sequential steps. First, an approximation of the demand schedule for each point in time must be developed external to the model. Secondly, an approximation of transportation rate savings afforded by the system must be available. Finally, the capability to evaluate the effects of aggregate system traffic levels on the rate structure for each individual traffic movement must be available. These topics are highlighted in the following paragraphs.

DEMAND PROJECTIONS

For application of the conceptual model, traffic demand input must not be constrained by the existing system definition. System constraints can be

embedded in the model itself in the form of interrelationships between aggregate system traffic, system physical capacity, and costs for individual movements. Consequently, initial model shipment inputs should include projected levels of potential traffic which assume that any existing and potential system bottlenecks will be eliminated. Application of the model itself will then constrain traffic only to those levels which may realistically occur, given the specified system definition, the origin-destination and commodity mix of demands, and the relationship between waterway charges and least-cost alternative charges.

The development of unconstrained traffic demand projections poses several problems, depending on the method of projection. Statistical analysis of historical flows and correlation with controlling economic parameters can result in projects which exhibit waterway constraints if a portion of the historical period exhibited such constraints. Use of shipper survey techniques to determine the future plans of individual waterway users can also result in projections which reflect system bottlenecks; some waterway users may consider such constraints in planning future transportation strategies, while others may not have a clear understanding of the relationships between such constraints and internal shipping costs. Likewise, market analyses and modal-split investigations can reflect transportation system constraints if the historical patterns of production and shipment have been influenced by constraints. Even the use of interregional, input-output analysis techniques are subject to the same problems since historical data must be used to construct the initial quantative relationships between economic sectors and regions.

The later section "Model Application - Shipment List" provides a full explanation of procedures and assumptions used. In short, two traffic demand projection sets were used in this study. The first was based on the OBERS 1980 projections and was applied to the 1979 WCSC commodity movement data. The second set of projections used were developed by A. T. Kearney for the TTW traffic.

RATE ESTIMATES

The Corps maintains a full record of individual dock-to-dock traffic

movements through data maintained by the WCSC. Within the WCSC system, commodities are uniquely classified using a detailed 4-digit code.

Because of the many thousands of individual movements which occur on the inland waterway system in any single year, it is neither feasible nor practical to model individual dock-to-dock shipments. Even after consolidating shipments to annual movements between a pair of docks, about 143,155 such movements of 4-digit commodities occurred on the system defined for this study in 1979. For modeling purposes, the number must be condensed considerably. Consequently, commodity groupings were consolidated into 15 aggregations, and docks consolidated to "port equivalents." In this way, the number of origin-destination commodity cells in the traffic matrix is substantially reduced to about 1,387. Rate data must also reflect this level of aggregation.

Rate studies were initiated with the compilation of data for movements on the BWT and projected rates for the TTW. Rate data collected by the Ohio River Division for use in the Gallipolis and Lower Ohio River studies were used for the traffic that utilized the Ohio River. Rate data gathered by the St. Louis District for the traffic using the IHNC that did not use the BWT served as the basis for this additional traffic. Each cell in the resultant matrix contains charges per ton for the waterway line-haul activities, charges per ton for all activities associated with the waterway routing, and the total charges per ton for the least-cost alternate waterway or overland routing, whichever applied.

The rate matrices initially developed were for different years and were subsequently updated to October 1981 price levels. Since actual rates being charged by carriers were used to develop the matrix, it reflects the waterway system definition and aggregate system traffic levels existing at the time that base data were being collected. Since the many waterway shippers could not possibly know what rate levels would be appropriate under conditions of different aggregate traffic levels or system definitions, waterway costing methods must be used to determine such rates. Pursuant to guidance provided by the Water Resource Council, rates for alternative least-cost overland modes are generally assumed to remain unchanged.

WATERWAY SERVICE COST ANALYSIS

As stated previously, unit waterway costs vary considerably from one movement to another. If a waterway operator were bidding on a transportation contract, his analysis would consider many factors relevant to the individual movement, as well as to his own equipment availability and the possibility of obtaining backhauls. Transit times would entail the accumulation of the component times. Times required for lock service would simply represent "given's" in his formula which would be derived from operational experiences. In short, the analysis would represent a static situation where any influences on his costs due to aggregate traffic levels and system capacity would be internalized indirectly by keeping records of recent operations. Such an analysis fails to quantitatively recognize the parameters pertinent to this study.

The ability to internalize system capacity and aggregate industry operations has been limited historically because of the vast number of computational requirements. With the development of computer languages which provide efficient matrix computation and data storage have come several waterway-costing computer models. They vary in level of detail, in the handling of transit time computations, as well as in the maximum size of the system handled.

The models selected for this study were a combination of the TCM and a revised WAM. This allows the use of an overall system costing model that can size the fleet for changing conditions on the waterway system and a simulation model that allows the determination of the effects of locks and other waterway constraints on the traffic, in particular increased service and delay times. These models are discussed further below.

TCM/WAM COST OUTPUT VERSUS TRANSPORT RATES

The conceptual model assumes that any changes in waterway transportation costs which result from changes either in aggregate traffic levels or in system specifications would induce a corresponding proportional change in waterway line-haul rates. For example, if TCM/WAM output showed that for a specific movement waterway line-haul costs increased by 20 percent when

aggregate traffic increased from 180 to 230 milion tons, then the rate charged the shipper would also increase 20 percent.

Theoretically, it should be possible to use the TCM/WAM to very nearly replicate the waterway line-haul rates determined from transportation rate surveys. This is possible by using the aggregate traffic levels that actually were occurring at the time of the rate study as inputs, and defining the system under conditions that existed at the time of the studies. In actuality, this can never be done precisely. Too many assumptions must be made in the analysis, and there exist too many unknowns regarding specific procedures the many waterway operators use to establish operating patterns. Waterway operators are competitors whereas the TCM/WAM optimizes as if the industry were a single monopoly. The TCM/WAM assumes perfect knowledge of all factors affecting costs; all waterway operators are not afforded prior perfect knowledge of the cost items which will face them. Also, the overall analysis assumes that the results are insensitive to the aggregation of individual movements to model port-to-port commodity groupings.

Accepting the fact that modeled costs will never correspond on a movement-by-movement basis with actual rates being charged shippers, procedures have been developed which assume that incremental changes in modeled costs will be reflected on a proportional basis in the rates. The procedures form the basis of a supplementary computer routine known as the "Marginal Economic Analysis (MEA) Postprocessor." In the development of this routine, it was recognized that total waterway transport charges could not be adjusted in direct proportion to differences in modeled waterway line-haul costs. Consequently, the base rate matrix developed for use in this analysis shows waterway line-haul rates as a separable component of the total routing charge. For any future TCM/WAM run, movement-specific costs are compared with the costs which correspond to the base-condition model run; the percentage change is applied to the base waterway line-haul rate; and the nonline-haul charges (unchanged) are added to the revised line-haul rate to obtain the new total waterway routing charge.

No adjustments are made in the conceptual model to either the nonline-haul water routing charges or the least-cost overland routing charges. The

changes made in the water line-haul rates are adjustments which reflect increases or decreases in transit time and optimum tow configurations attributable to either a change in aggregate traffic volumes or a change in the physical system itself.

MARGINAL ECONOMIC ANALYSIS

The theoretical application of marginal economic analysis generally involves smooth, uniform, and marginal cost of benefit curves. However, real-world economics are not often that simple. Use of the ton-mile as the unit of measure for system output to some extent standardizes the view of production throughout the system. Even with this standardization, some variability remains in the characteristics of output.

To a great extent, the waterway system produces for a differentiated market. In other words, the aggregate demand for waterway system output is really a collection of many demands, each slightly different from the others. Variations arise due to differences in the commodities shipped, costs of production throughout the system, and characteristics in the rate structure for least-cost overland or alternate waterway routings.

As a result of differentiation in output, relationships between marginal costs and rate savings at alternative levels of output are somewhat erratic. In marginal analysis, incremental outputs (which occur in uneven quantities corresponding to movement size) are ranked in such a fashion as to form the smooth benefit curve. Waterway line-haul rates may tend toward a smooth curve, but marginal total waterway routing charges (marginal costs) will be less inclined to represent a smooth trend. However, since the MEA analysis relies on the average and marginal rate savings, the unevenness of the marginal cost curve is not significant.

Marginal economic analysis applications in this study are basically twofold. The first application is used to determine the aggregate level of traffic that will move on the system and through the BWT study area for each of the three relevant system production levels. Having arrived at these answers, the individual movements remaining on the waterway and those diverted to an

alternative route or mode can be identified. This process is repeated for each year of traffic demand projections and for the with and without conditions. For this study, structural remedies are contemplated only for the Oliver Lock with operational improvements at Demopolis and Coffeeville Locks. Pickwick Lock is improved with the 1,000- by 110-ft lock chamber that is currently under construction for the future years. Nonstructural measures were considered at the Oliver Lock; however, it was found that the capacity could not be increased significantly. The nonstructural measures primarily included the construction of mooring cells to improve the double locking procedure. The use of mooring cells approximated the ready-to-serve option. These conditions were used for all future without project tests.

The second application of marginal analysis is the determination of incremental benefits for the replacement plan. For the selected plan, accumulated traffic levels and incremental benefits and costs are computed for each year. Costs associated with each alternative represent the Federal costs for construction and operation and maintenance. Average annual benefits and average annual costs are estimated to determine economic feasibility.

In the first analysis, the objective was to determine traffic levels. Only those costs incurred by the waterway shippers are deterministic in this decisionmaking process. Shippers use only those rates and charges which are internal to their production function to compute costs and determine the extent of waterway usage. Therefore only those portions of waterway facility costs which have been passed on to them by the towing industry are internalized.

In the second analysis (see main body of report), objectives are to determine the nature and timing of Federal investment. Costs pertinent to these decisions are those borne by the Federal Government in making such investments. If portions of these costs are passed on to ultimate waterway shippers through user charges and subsequent increases in waterway freight rates, then the benefits credited to each alternative have been reduced by an equal amount. In effect, this represents a transfer payment and consequently, benefits must be adjusted upward to offset this effect.

ATTACHMENT 3

MODELING SYSTEM DESCRIPTION

EXISTING MODELS

INSA MODELS

The original INSA package, developed in 1974-1975 by the Office, Chief of Engineers (OCE), was a planning capability comprising an integrated system of computer models, data, and planning procedures. The INSA system of models was designed to replicate on a day-to-day basis the national market system and the role of inland waterway transportation within that system.

Within INSA, one pair of models, consisting of the Commodity Flow and the Multimodal Models, simulated the national market system and the complete national transportation system. The Multimodal Model was designed, for example, to model shipments over waterways, railroads, highways, pipelines, and even electrical transmission systems. A second pair of the models, consisting of the Flotilla and Navigation Simulation Models, simulated inland waterway transportation in detail. More complete information on these four models is available in the INSA documentation of these models.

Since 1975, extensive testing of these models has been carried on by OCE, by the Ohio River Division, by various local Corps Districts, and by a number of other Federal, State, and private planning organizations. As a result of this testing, the first two of these models, the Commodity Flow and Multimodal models, are no longer used by the Corps for systems analysis purposes. This is due both to the complexities of data requirements for these models and difficulties in validating the model's logic.

MODIFICATIONS TO INSA MODELS

Considerable work has been accomplished, however, with the Flotilla and Navigation Simulation models, particularly in the Ohio River Division. Extensive testing of the Simulation Model was undertaken by the Pittsburgh District, and several modifications to this model were made with the help of

CACI, Inc., and other private consultants. Primarily these corrected and improved the model's logic and improved the simulation of locking procedures. The updated version of the model is known as the Waterway Analysis Model (WAM).

Perhaps the most significant result of ORD coordination since 1974 has been the development of the Tow Cost Model (TCM), as well as various supplemental computer programs such as the MEA Postprocessor. The TCM is an extensive upgrading of the original Flotilla model. This model allows for a thorough economic analysis of overall system impacts arising from individual improvements at any point in the system. The model is most applicable for analysis of navigation elements which are heavily dependent on maintenance of locks and dams, but requires good estimates of lock capacities and traffic-delay relationships as input. Huntington District has been primarily responsible for upgrading and verification of the TCM, and for development of the MEA procedures. Louisville District concentrated on review and development of methodologies for estimating lock capacities and traffic-delay relationships.

SHORTCOMINGS OF EXISTING MODELS FOR PRESENT STUDY

While these models have been used sucessfully in several major studies, there were several shortcomings that created limitations in the usefulness of the models. One of the limitations in all of the systems analysis models that have been created and used by the COE has been the inability to model accurately the impacts of constrained channels. The BWT is a narrow waterway with many sharp bends wherein traffic is restricted to one-way operations. Therefore one of the important considerations of this study was the impact these bend constraints have on the capacity and costs of operation. Two important factors have to be included:

1. The delay caused by the one-way restriction.
2. The reduced transit speeds required by the difficult maneuvering conditions.

Studies performed in the 1970's indicated that the bends on the BWT before Demopolis, Alabama, could prove to be a major constraint. However, these

earlier studies were based on the following parameters:

- 300-ft waterway
- Dual 110- by 600-ft lock chambers at Coffeeville and Demopolis
- Two-way 8-barge tow traffic

Such is not the case of the present study, which is based on the existing project dimensions below Demopolis, Alabama.

It is felt that the best way to analyze these impacts is with a simulation model study to address the potential delays at the bends.

Another limitation of the WAM was the extreme detail included in the model. The WAM was developed to emulate the complete operation of the entire waterway system including all of the dispatching and operational decisions made by waterway operators. This excess of detail creates extremely high operating costs. In addition, the use of this model in comparative analyses is limited due to the nature in which the tow movements are generated. Therefore it is difficult to interpret the results of similar commodity movement levels under different waterway conditions.

In order to use the TCM, a method for determining the physical capacity of the locks and the delay-lock utilization relationship is required for each lock. Presently there are two accepted methods for accomplishing this. One is to use a simulation model such as WAM; the other is to use an analytical approach, such as LOCALC or LOKCAP. The limitations for using WAM have just been discussed. LOCALC and LOKCAP both require a fixed description of the commodity mix, the commodity-barge relationship, the tow-size distribution, and the chamber assignments for lockages. While reasonable estimates of the lock physical capacity are possible under the stated conditions, as future traffic projections are analyzed these conditions change; and when using the TCM and MEA method of analysis, they change as the marginal traffic is eliminated in order to obtain new estimates of the operating costs and rates within a given future condition. Furthermore, the delay curve estimates are based on a very simplified queuing theory relationship that is quantified through empirical data. As conditions deviate from that empirical data the derived

relationship's validity becomes questionable. If the empirical data do not include an adequate range of utilization levels, particularly in the 70 to 99 percent utilization range, the validity of the empirical relation at the most critical levels of use will not be adequately represented.

SYSTEM SELECTED FOR THIS STUDY

The requirements of this study and the limitations of the available models discussed above dictated that an improved and expanded modeling system be developed in order to study the BWT improvements. An earlier study of the Lower BWT below Demopolis Lock and Dam had indicated that a large number of bends would require widening and/or the development of cutoffs to overcome anticipated constraints on that section of the BWT. Therefore a detailed analysis of the impacts of bendway constraints on the economics of the navigation traffic was necessary.

It was decided that the best approach would be to modify and generalize the available modeling and economic analysis system that had been developed and tested over the past 7 years. The TCM system provided the basic means for determining the resulting costs of waterborne commodity movements under various conditions and waterway systems. The MEA provided the method for determining the benefits in terms of rate savings and traffic that is marginally uneconomical under the tested operating conditions. Finally, WAM could provide the base for simulating the capacities and delays at locks and the transit and delay times at bends under each operating condition.

The general outline of the system used in this study will be described below. First, because both the TCM and the WAM required almost identical data although in different formats, a Preprocessor Program was developed that would allow a single set of data to be developed that would describe the waterway and operating conditions. This preprocessor would then generate the data required for both programs in the proper format.

The WAM model was modified extensively. First, it was modified to eliminate the simulation of the total dispatching and equipment operation. Instead it would accept externally generated shipments assigned to preconfigured tows.

These tow shipments would arrive in the system at randomly designated times at assigned ports and destined to specified ports. These shipments would be generated from the Resource Requirements File generated by the TCM. In addition, WAM was modified to enable the simulation of operations at a bend. Finally, the WAM output was expanded to include results of the bend simulation and information for the Resource Requirements File. These data would be incorporated into the Resource Requirements File produced by the TCM and used in the MEA.

TOW COST MODEL-ANNUAL VERSION

The TCM consists of two programs, the Resource Requirements Program and the Resource Requirements Program Postprocessor. The Resource Requirements Program determines the least-cost set of towing equipment for use on the system, based upon a given set of annual origin-destination commodity flows and system configuration and specifications. Calculations of direct costs borne by shippers are made. Capabilities exist in the program for the specification of any level of user charges. Output from the Resource Requirements Program is denoted as the Resource Usage File (RUF). Discussions of the detailed operations performed by the program are described in the model documentation and in Appendix N, General Design Memorandum, Gallipolis Locks and Dam Replacement.

The RUF serves two purposes. First, it provides the definition of tow movements required to transport the commodities between the origin and destination points and the optimum size tow to perform those movements for use in generating the tow movement list required by the WAM. Second, it is the source of tow movement characteristics and operational timings used to generate the transportation costs used in the MEA. This file is input to the Resource Requirements Program Postprocessor which generates a series of individual Trip Reports which contain detailed carrier cost data. Output is to a computer file with user option for selected hardcopy outputs. The user also controls the selection of origin-destination pairs for which Trip Reports are desired. As used in this study, data from the Trip Report File represent input to the MEA Postprocessor which was developed by the Huntington District. The MEA Postprocessor as well as routines developed to access the Trip Report File will be discussed subsequently.

MODIFIED WATERWAY ANALYSIS MODEL

The WAM is a model of waterway operations that simulates the events or activities that take place as a tow moves from the point of origin to the destination of a commodity movement. Statistics are recorded on the details of these movement events for printed reports and for output data files.

As originally designed, WAM involved detailed simulation of the loading and unloading of barges, the location and transportation of empty barges to the ports needing extra barges, the location of available towboats required to push the tow, and all the attendant record keeping necessary to manage the fleet. For purposes of this study, these functions were removed and replaced by an external event list that contained a full description of the tow movements required to transport the commodities expected to be moved during the simulation period. This list includes the tow type, barge type, transportation class, tonnage, origin port, destination port, number of empty and loaded barges, and the time of entry into the simulation.

The external event list is generated from the RUF created by the TCM. The RUF identifies the number of round trips, the towboat class, barge type and tow size selected, the barge load allowed, and the empty backhaul factor for each segment of a transportation class movement. A movement scheduling program was written that schedules each tow movement that would likely take place during the simulation period to be tested. If a movement is refleeted, each segment of the movement is scheduled based on the RUF description of those segments. Backhaul potential for each segment is taken into account.

A method for modeling the transit of tows through restricted bends on channels was added to the WAM model. In addition to defining reaches through which tows travel, a bend may now be defined. Upon arrival at a bend, the simulation model will determine if another tow is in the bend or if a downbound tow is about to enter the bend. If the bend is not in use, the tow is allowed to enter that reach of the system. If the bend is occupied or is about to be occupied, the model must then determine if the tow approaching the bend can enter, i.e., are the channel and tow sizes such that two-way traffic is allowed. The channel width required by both tows is determined from the

design curves contained in Engineer Manual 1110-2-1611, Layout and Design of Shallow-Draft Waterways, dated 31 December 1980. For purposes of this study the curves for 90-degree central angles and 6-fps velocities were used since most bends were long and the velocities at high discharge rates are around this speed. If the required width is greater than the width of the channel, then the upbound tow is required to wait in queue until the channel is clear and the delay is recorded.

The reports generated by the WAM were expanded to include a report that describes the activities at the bends. In addition, a new data file can be generated by the WAM that contains a description of the time spent in transit, lockage, delay at locks, transiting bends, delay at bends, and loading and unloading operations. This data file can then be processed through a utility program that groups the individual tow trip reports for the same movement segment and creates a WAM RUF for use by the Resource Requirements Program Postprocessor.

MARGINAL ECONOMIC ANALYSIS PROGRAM

The MEA program used is basically the one developed by the Huntington District. The procedure is designed to provide a general approach for use in developing marginal cost and benefit relationships for waterway systems analysis. The MEA program uses costs developed from the measures of loading and unloading, transit, locking, and delay times as developed by the TCM or as modified by the WAM. Costs are applied to each of these measures independently for each movement segment for either the base or future condition being tested. As the delays increase with escalating traffic levels or the system efficiency is improved when the system is modified, the base rate as determined in the rate survey is modified to reflect the changes in line-haul costs. The MEA displays the transportation class movements ranked in order of decreasing marginal rate savings in order to aid in the diversion of traffic from the system. In addition, the MEA displays traffic, cost, and rate savings data for movements common to specific reaches of the system as designated by the user. In this particular study, this information was displayed for the total BWT system, as well as Oliver, Coffeeville, and Demopolis Locks.

A more detailed description of the MEA program is presented in Appendix N, General Design Memorandum, Gallipolis Lock and Dam Replacement. This reference describes the program logic in detail. Two changes were made for the purposes of this study. The first was to modify the code so that reports for the BWT system would be generated. The second modification actually was made in the Resource Requirements Program Postprocessor. Since the WAM was generating a RUF which included delay times at bends and was generating delays at locks based on simulated queuing events which were believed to give a more realistic measure of the delays than the queuing theory curve used by the TCM, those movement segments that had records generated by the WAM in the RUF had the times for transit, locking, and delay times from the WAM model substituted into the TCM RUF before being processed by the MEA. The transit time included the transit times for regular reaches and bends and the delay times included the delays recorded for locks and bends.

MOVEMENT DIVERSION

When the capacity of a lock is exceeded, delays at the lock become excessive and the costs of operation escalate rapidly. Movements of commodities on the waterway will be diverted to alternate modes of movement, particularly the movements that have negative rate savings. When the capacity of a lock was exceeded as identified in the WAM results, traffic had to be removed in order to complete the simulation runs. Therefore a procedure developed by the Huntington District was used to divert traffic from the waterway.

This procedure uses the list of traffic movements ranked by rate savings created by the MEA program. This list is searched beginning with the largest negative savings movement. As each lock is located that has been identified as having excess tonnage using the lock, that movement is flagged. If a movement uses more than one lock that has too much traffic, that movement is marked for each lock. This continues until the tonnage requested to be removed from the locks is identified. Those movements involving more than one lock are removed first. Then the remaining tonnage is removed from the shipment list in order of decreasing negative rate savings. If the last shipment removed for a lock is larger than the tonnage required to satisfy the request, only that portion required to reduce the tonnage to the desired level will be removed.

ATTACHMENT 4

DATA TABLES - MODEL APPLICATIONS

Table 1

BWT Study Traffic Projections

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
3	68	5	0.0	7	15	17	19	23	24
4	39	12	0.0	9	13	15	16	19	27
4	49	5	0.0	4	8	9	10	13	19
4	61	12	0.0	13	17	19	21	25	35
4	65	12	0.0	6	9	10	10	13	18
4	73	12	0.0	9	12	13	14	17	24
4	75	12	0.0	10	13	14	16	19	27
4	88	12	0.0	8	10	11	13	15	21
5	47	5	0.0	13	27	30	34	41	60
5	88	10	100.0	22	28	31	33	38	53
6	41	4	0.0	36	64	78	94	124	214
6	44	12	0.0	27	36	40	43	52	73
6	45	9	100.0	14	18	20	21	25	34
6	47	5	0.0	8	18	20	22	27	40
6	51	4	0.0	31	45	53	62	81	135
6	51	10	100.0	11	14	16	17	20	27
6	68	10	100.0	10	13	14	15	18	24
6	68	12	0.0	31	42	46	50	60	85
6	69	12	0.0	21	29	32	36	42	60
6	73	9	100.0	9	12	13	14	16	22
6	75	12	0.0	182	244	266	291	347	490
6	75	14	0.0	5	7	8	9	11	15
6	77	12	0.0	76	101	112	124	147	207
6	88	10	100.0	12	14	16	17	20	28
6	88	12	0.0	102	136	149	163	194	276
6	93	12	0.0	9	12	13	15	18	25
6	102	12	0.0	1	16	18	21	28	44
7	44	12	0.0	8	10	12	13	15	22
7	45	9	100.0	13	17	18	19	23	31
7	74	9	100.0	6	7	9	9	10	15
7	75	10	100.0	7	9	10	11	13	18
7	88	10	100.0	11	14	15	15	18	26
7	93	10	100.0	25	34	35	39	45	62
7	93	14	0.0	26	35	38	42	50	71
8	51	4	0.0	33	49	57	68	87	146
8	65	7	0.0	9.	12	13	14	16	22
9	39	12	0.0	6	8	8	9	11	16
9	51	4	0.0	5	8	10	11	15	25
9	64	12	0.0	5	7	8	9	11	15
9	68	12	0.0	5	7	8	9	11	15

(Continued)

(Sheet 1 of 35)

Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
9	74	4	0.0	16	48	62	80	108	196
9	74	9	100.0	11	13	15	16	18	26
9	88	10	100.0	9	12	12	14	16	22
10	39	12	0.0	22	30	33	36	44	62
10	43	12	0.0	31	40	44	49	58	83
10	45	9	100.0	8	11	11	12	14	20
10	47	12	0.0	16	21	23	26	31	43
10	59	12	0.0	14	19	22	24	28	41
10	62	12	0.0	9	13	14	15	18	26
10	65	10	100.0	10	12	13	14	17	23
10	68	12	0.0	28	38	42	46	55	78
[illegible]	69	12	0.0	45	60	65	71	85	120
10	72	12	0.0	8	10	12	13	16	22
10	73	12	0.0	29	39	43	46	55	78
10	75	12	0.0	128	172	188	204	242	346
10	75	14	0.0	6	8	8	9	11	16
10	77	12	0.0	78	105	115	125	151	213
10	88	12	0.0	36	50	54	59	71	101
10	88	14	0.0	5	7	9	10	11	16
10	93	12	0.0	9	12	13	14	17	24
10	93	14	0.0	7	10	11	13	15	22
11	45	9	100.0	6	8	9	9	11	15
11	65	9	100.0	12	15	17	18	21	29
11	68	9	100.0	6	8	9	9	11	15
11	74	9	100.0	71	91	98	104	123	168
11	75	9	100.0	30	38	40	43	50	69
11	88	10	100.0	8	10	11	11	14	20
12	41	4	0.0	14	27	33	40	53	93
12	41	12	0.0	6	9	10	11	14	22
12	51	4	0.0	69	101	119	140	180	302
12	56	5	0.0	11	26	30	34	40	60
12	68	5	0.0	8	16	19	21	26	39
12	72	10	100.0	5	8	9	10	13	20
12	73	9	100.0	5	8	8	9	12	18
12	75	11	0.0	3	9	11	14	20	36
12	93	10	100.0	5	7	8	9	11	16
13	39	12	0.0	33	48	53	60	74	113
13	43	12	0.0	16	22	26	29	35	54
13	54	12	0	23	34	37	41	51	80
13	59	12	0	47	65	76	84	105	160

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
13	65	12	0.0	163	231	259	291	358	543
13	68	9	100.0	7	9	12	13	17	25
13	68	12	0.0	63	88	99	112	138	209
13	69	12	0.0	13	20	22	26	32	49
13	73	9	100.0	20	28	32	36	45	69
13	75	12	0.0	48	68	76	86	106	160
13	76	12	0.0	15	22	24	28	34	53
13	88	10	100.0	12	18	20	22	28	44
13	88	12	0.0	38	53	61	68	84	129
13	93	10	100.0	11	16	18	21	26	40
14	39	12	0.0	7	9	11	12	15	23
14	47	5	0.0	716	1498	1690	1905	2348	3566
14	49	5	0.0	1794	3755	4236	4776	5885	8937
14	54	12	0.0	12	17	19	21	27	42
14	64	12	0.0	6	9	10	11	14	22
14	65	12	0.0	18	25	28	32	39	60
14	68	5	0.0	4	9	10	12	15	22
14	68	12	0.0	20	29	33	37	45	69
14	69	12	0.0	10	14	16	18	22	33
14	95	12	0.0	1	20	23	27	35	58
15	73	10	100.0	16	23	27	30	38	59
16	40	6	0.0	6	10	12	13	16	24
16	50	6	0.0	18	30	33	37	45	67
16	59	12	0.0	11	17	19	21	26	40
18	49	5	0.0	83	201	227	257	315	555
18	53	5	0.0	84	203	230	260	319	562
18	88	5	0.0	66	161	183	207	253	446
19	45	5	0.0	5	12	14	16	20	35
19	88	5	0.0	13	32	36	41	50	88
20	54	9	100.0	7	10	12	14	18	28
20	59	9	100.0	76	108	124	141	175	272
20	61	9	100.0	17	25	28	32	40	63
20	63	9	100.0	5	8	9	10	12	20
20	75	9	100.0	47	67	77	87	109	170
20	82	9	100.0	1	21	24	28	36	60
20	88	5	0.0	5	12	14	16	19	35
20	91	9	100.0	15	22	25	29	36	56
21	68	5	0.0	4	9	11	13	16	27
22	47	5	0.0	73	162	189	219	279	450
22	57	5	0.0	13	29	34	40	51	82

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
23	39	10	100.0	12	21	25	29	36	58
23	40	5	0.0	19	44	51	59	76	122
23	40	10	100.0	9	16	19	22	27	44
23	41	10	100.0	8	14	17	20	25	39
23	43	10	100.0	48	83	97	113	142	223
23	44	5	0.0	304	679	789	916	1164	1882
23	45	5	0.0	685	1525	1773	2059	2618	4230
23	45	9	100.0	4	8	9	11	14	22
23	47	5	0.0	25	57	66	77	98	159
23	52	11	0.0	19	29	34	40	51	86
23	53	5	0.0	884	1966	2284	2654	3372	5448
23	54	5	0.0	17	39	45	52	67	109
23	54	10	100.0	6	11	12	14	18	29
23	54	12	0.0	6	11	13	14	18	30
23	56	5	0.0	14	31	37	43	54	89
23	57	5	0.0	13	29	34	40	51	82
23	59	5	0.0	28	63	74	86	109	177
23	63	12	0.0	10	17	20	23	29	47
23	65	5	0.0	225	502	584	678	861	1393
23	65	10	100.0	50	87	101	118	148	234
23	65	11	0.0	6	9	10	11	14	21
23	65	12	0.0	5	8	9	11	14	22
23	66	5	0.0	745	1658	1926	2237	2844	4594
23	67	10	100.0	5	8	10	12	15	23
23	68	5	0.0	3	9	10	12	16	27
23	68	12	0.0	8	12	14	17	21	35
23	69	12	0.0	4	8	9	11	14	23
23	73	9	100.0	23	39	46	53	68	107
23	73	10	100.0	14	24	28	32	40	64
23	75	5	0.0	376	840	977	1134	1443	2332
23	75	9	100.0	16	26	32	37	47	73
23	75	12	0.0	19	29	34	40	50	81
23	76	9	100.0	10	18	22	26	32	51
23	76	10	100.0	12	21	25	29	36	58
23	77	9	100.0	10	18	21	25	31	49
23	88	5	0.0	16	38	44	53	67	108
23	88	9	100.0	18	31	36	42	54	86
23	88	10	100.0	39	69	81	94	119	189
23	88	12	0.0	5	8	9	11	14	23
23	91	5	0.0	72	162	188	219	279	457

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
23	93	10	100.0	32	54	63	73	92	143
24	39	10	100.0	75	129	150	175	220	347
24	40	10	100.0	15	26	30	35	44	70
24	43	10	100.0	37	63	74	87	109	171
24	44	5	0.0	61	135	157	183	233	376
24	44	10	100.0	15	27	31	37	46	74
24	45	5	0.0	120	274	316	365	459	761
24	45	10	100.0	10	18	21	25	31	50
24	47	5	0.0	9	21	25	28	34	61
24	53	5	0.0	413	999	1131	1282	1570	2760
24	59	5	0.0	79	176	205	238	303	490
24	59	10	100.0	23	39	46	54	67	106
24	65	10	100.0	33	57	67	78	98	155
24	71	10	100.0	16	27	32	37	46	73
24	75	10	100.0	5	9	11	13	16	26
24	76	10	100.0	7	12	14	17	21	34
24	88	10	100.0	51	88	103	119	150	238
24	91	5	0.0	38	91	105	120	152	254
24	91	10	100.0	4	8	9	11	14	22
25	61	11	0.0	7	10	11	12	14	21
25	68	2	0.0	12	18	20	23	27	40
25	72	11	0.0	7	12	15	18	25	44
25	83	1	100.0	46	62	68	74	89	128
25	93	10	100.0	5	8	9	10	12	18
26	39	10	100.0	9	13	16	18	22	35
26	44	1	100.0	18	25	28	30	36	52
26	45	1	100.0	9	12	13	14	17	25
26	52	10	100.0	135	203	231	263	327	506
26	57	10	100.0	10	16	18	20	25	39
26	68	1	100.0	43	57	63	69	83	118
26	68	7	0.0	5	8	9	10	13	20
26	68	10	100.0	117	176	200	228	283	438
26	72	1	100.0	12	17	18	21	24	36
26	73	1	100.0	108	144	158	174	208	296
26	73	7	0.0	40	61	69	79	98	153
26	73	9	100.0	21	32	37	42	52	81
26	73	14	0.0	10	15	17	19	24	36
26	75	12	0.0	6	9	10	12	14	22
26	75	14	0.0	39	59	66	75	92	140
26	88	1	100.0	1339	1777	1956	2154	2570	3665

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
26	88	2	0.0	40	52	72	82	101	157
26	88	5	0.0	116	200	225	252	316	493
26	88	7	0.0	54	82	93	107	133	206
26	91	1	100.0	16	22	24	26	31	45
26	93	10	100.0	11	18	20	23	29	44
26	100	12	0.0	1	13	14	15	17	23
28	47	5	0.0	1227	2106	2368	2666	3324	5175
28	53	5	0.0	456	783	891	992	1237	1925
28	60	5	0.0	31	53	60	67	84	131
28	61	5	0.0	40	69	78	88	110	171
28	66	5	0.0	35	60	67	76	95	148
28	88	2	0.0	17	24	26	29	34	50
28	88	5	0.0	64	110	124	139	174	271
29	49	5	0.0	54	94	107	121	153	242
29	53	5	0.0	25	44	50	56	71	113
29	54	5	0.0	111	193	219	250	313	497
29	54	12	0.0	10	17	19	24	31	51
29	56	5	0.0	9	17	19	22	27	44
29	57	5	0.0	25	45	51	58	73	117
29	58	5	0.0	6	11	13	15	19	30
29	59	12	0.0	29	45	53	63	82	138
29	61	14	0.0	5	8	9	11	15	25
29	68	14	0.0	5	9	10	12	16	27
29	73	14	0.0	12	18	22	26	33	56
29	76	14	0.0	9	14	17	20	27	45
29	88	1	100.0	174	233	256	282	338	484
29	88	5	0.0	41	72	82	93	117	185
29	91	5	0.0	236	409	464	527	663	1049
30	39	10	100.0	11	15	17	20	25	40
30	40	10	100.0	25	35	40	45	57	90
30	43	10	100.0	10	14	16	18	23	37
30	45	10	100.0	30	42	48	55	70	110
30	51	9	100.0	10	14	16	18	23	36
30	59	10	100.0	9	12	14	16	21	33
30	61	10	100.0	6	8	9	11	14	22
30	75	10	100.0	243	339	387	444	557	874
30	88	10	100.0	54	75	86	98	123	194
31	66	10	100.0	12	17	20	23	29	45
31	71	11	0.0	12	26	33	42	57	102
31	72	11	0	35	61	76	92	121	213

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
31	73	6	0.0	46	80	90	103	129	205
31	90	5	0.0	9	15	17	20	25	40
32	42	5	0.0	12	27	31	36	46	76
32	44	1	100.0	14	18	20	22	27	39
32	47	5	0.0	250	532	619	719	916	1486
32	55	5	0.0	22	46	54	63	80	131
32	56	5	0.0	83	178	206	240	307	498
32	57	5	0.0	83	179	208	242	308	501
32	59	5	0.0	96	204	238	277	354	574
32	60	5	0.0	10	21	24	28	36	59
32	61	5	0.0	35	75	87	101	130	211
32	68	1	100.0	59	76	84	92	110	158
32	68	5	0.0	375	798	929	1080	1375	2230
32	72	5	0.0	5	10	12	14	18	30
32	73	1	100.0	6	8	9	10	12	17
32	88	1	100.0	185	239	264	292	349	500
32	88	5	0.0	75	159	185	216	275	446
32	88	7	0.0	224	320	360	404	497	750
32	90	5	0.0	78	166	193	224	286	464
32	91	5	0.0	220	469	546	635	808	1311
33	42	5	0.0	122	261	303	353	449	728
33	47	5	0.0	348	742	863	1003	1277	2071
33	53	5	0.0	1686	3589	4172	4850	6176	10013
33	67	1	100.0	17	22	24	27	32	47
33	68	5	0.0	819	1745	2029	2359	3004	4870
33	72	5	0.0	5	11	13	15	19	31
33	84	5	0.0	1	1227	1432	[illegible]	2170	3529
33	88	1	100.0	91	117	129	142	171	244
33	88	5	0.0	1872	3983	4632	5384	6856	11118
33	90	5	0.0	49	105	122	142	181	294
33	92	5	0.0	13	27	32	37	47	77
33	102	5	0.0	1	503	587	684	890	1450
33	105	5	0.0	1	503	587	684	890	1450
34	56	5	0.0	7	14	17	20	25	41
34	57	5	0.0	172	368	428	498	636	1031
34	68	1	100.0	15.	20	22	24	29	41
34	88	1	100.0	45	58	66	72	86	124
35	49	5	0.0	8	17	20	[illegible]	[illegible]	[illegible]
35	55	5	0.0	17	37	43	51	65	105
35	56	5	0.0	34	73	86	100	127	207

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
35	66	5	0.0	95	202	235	273	348	565
35	67	1	100.0	6	8	8	9	11	16
35	68	1	100.0	19	25	28	31	37	53
35	68	5	0.0	22	50	58	67	85	139
35	68	10	100.0	8	11	13	14	18	27
35	71	6	0.0	4	8	10	12	15	25
35	72	1	100.0	11	14	16	18	21	30
35	73	1	100.0	38	49	54	59	71	101
35	75	14	0.0	14	23	26	31	39	62
35	88	1	100.0	998	1287	1419	1564	1869	2672
35	91	1	100.0	9	12	14	15	18	27
36	40	5	0.0	4053	8626	10029	11659	14846	24068
36	40	10	100.0	10	15	17	19	23	35
36	43	1	100.0	5	7	8	9	11	15
36	44	1	100.0	11	15	17	18	22	32
36	52	10	100.0	130	186	209	235	289	436
36	54	10	100.0	54	78	88	99	121	183
36	57	10	100.0	32	45	51	57	71	107
36	59	5	0.0	5	11	13	15	19	31
36	59	10	100.0	120	171	192	216	266	401
36	61	10	100.0	89	127	144	162	199	300
36	65	10	100.0	112	160	180	202	248	375
36	66	10	100.0	16	24	28	31	39	59
36	67	1	100.0	6	7	8	9	11	16
36	68	1	100.0	17	21	25	27	32	46
36	68	10	100.0	379	543	609	685	841	1272
36	73	1	100.0	59	76	83	91	109	157
36	73	7	0.0	15	22	25	28	35	53
36	73	10	100.0	34	49	55	62	76	115
36	76	10	100.0	14	20	23	25	32	48
36	88	1	100.0	929	1197	1320	1454	1738	2487
36	88	7	0.0	22	31	37	41	50	77
36	88	10	100.0	29	41	46	52	64	97
36	91	1	100.0	15	19	21	24	29	42
36	92	1	100.0	5	7	8	9	10	15
37	40	5	0.0	2642	5624	6539	7602	9680	15695
37	45	5	0.0	5	11	13	15	19	31
37	46	5	0.0	8	18	21	25	32	51
37	49	5	0.0	1155	2458	2857	3322	4230	6858
37	56	5	0.0	4	10	11	13	17	

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
37	67	1	100.0	36	47	51	57	68	97
37	68	5	0.0	768	1636	1903	2213	2818	4568
37	82	5	0.0	1	1846	2288	2824	4011	7636
37	84	5	0.0	1	1626	1926	2275	3096	5601
37	88	1	100.0	289	373	411	453	543	776
37	88	5	0.0	101	216	250	292	371	602
37	90	5	0.0	1169	2489	2894	3364	4284	6945
37	91	5	0.0	304	647	752	875	1114	1806
37	93	5	0.0	11	25	29	34	43	71
37	102	5	0.0	1	2118	2456	2849	3663	5843
38	53	6	0.0	1274	2246	2577	2957	3770	6131
38	53	11	0.0	109	160	189	222	286	477
38	55	5	0.0	42	74	85	97	124	204
38	56	5	0.0	81	144	165	190	243	397
38	68	5	0.0	693	1222	1402	1609	2052	3337
38	88	1	100.0	19	26	29	31	38	54
38	88	4	0.0	6	12	15	19	25	45
38	91	5	0.0	26	47	54	62	79	129
39	7	14	0.0	5	11	13	16	21	37
39	8	14	0.0	13	25	31	39	51	89
39	19	9	100.0	11	17	18	22	28	43
39	55	12	0.0	10	19	23	28	37	64
39	59	14	0.0	5	9	12	15	21	36
39	72	11	0.0	21	36	44	55	73	130
39	73	12	0.0	41	78	95	115	152	262
39	73	14	0.0	8	16	20	24	32	55
39	75	14	0.0	9	18	22	28	36	63
39	76	14	0.0	32	62	77	94	124	216
39	88	14	0.0	6	13	15	19	26	44
39	93	6	0.0	13	29	34	40	52	87
40	39	6	0.0	250	555	657	778	1005	1681
40	59	10	100.0	5	8	9	10	13	21
40	73	1	100.0	13	14	15	16	19	25
40	88	1	100.0	79	91	97	102	119	158
40	92	5	0.0	9	16	18	21	27	45
41	40	4	0.0	14	27	32	40	52	92
41	41	6	0.0	46	114	137	164	214	359
41	42	2	0.0	76	107	119	134	165	249
41	59	4	0.0	8	11	12	13	17	24
41	59	12	0.0	7	12	15	18	23	41

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
41	65	10	100.0	8	13	15	18	22	36
41	84	12	0.0	1	79	88	99	118	163
41	105	5	0.0	1	1353	1581	1842	2391	3890
41	105	6	0.0	1	64	71	80	96	138
42	42	2	0.0	18	28	31	36	44	68
42	44	9	100.0	9	13	15	17	21	34
42	49	9	100.0	14	21	24	27	34	54
42	51	9	100.0	7	11	12	14	18	28
42	74	8	0.0	5	11	13	16	22	40
42	84	5	0.0	1	4305	5148	6092	8295	13922
43	43	6	0.0	752	1856	2215	2644	3416	5706
43	44	5	0.0	157	387	462	552	713	1192
43	44	6	0.0	7	17	20	24	31	53
43	47	5	0.0	73	181	217	259	334	559
43	56	5	0.0	52	128	153	182	236	394
43	73	7	0.0	28	41	47	54	68	106
43	74	14	0.0	5	9	11	14	18	32
43	84	5	0.0	1	2477	2962	3505	4774	8008
43	84	12	0.0	1	102	113	126	150	207
43	84	14	0.0	1	11	16	21	40	123
43	88	7	0.0	28	44	49	58	72	114
43	91	5	0.0	18	45	54	64	83	139
44	23	10	100.0	5	8	9	11	14	22
44	24	10	100.0	10	17	19	22	28	44
44	42	2	0.0	340	561	647	747	940	1489
44	43	6	0.0	372	869	1030	1223	1579	2631
44	44	5	0.0	1151	2769	3297	3924	5069	8457
44	45	6	0.0	22	47	55	65	84	140
44	73	7	0.0	24	38	43	50	64	100
44	84	2	0.0	1	10	12	13	17	27
44	84	4	0.0	1	12	13	15	18	25
44	84	5	0.0	1	3344	3999	4735	6447	10820
44	88	7	0.0	70	110	127	147	186	292
45	6	10	100.0	14	22	26	29	37	59
45	12	5	0.0	29	52	60	68	87	144
45	18	5	0.0	22	39	44	51	65	107
45	20	9	100.0	24	38	44	51	64	101
45	44	6	0.0	47	84	96	110	141	232
45	45	2	0.0	28	46	53	62	78	123
45	45	6	.0	123	218	250	286	366	60

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
45	45	8	0.0	154	309	372	446	577	962
45	45	9	100.0	14	21	25	29	36	57
45	47	5	0.0	46	81	93	106	136	224
45	54	12	0.0	12	25	30	37	49	83
45	73	7	0.0	35	55	63	74	93	145
45	75	9	100.0	17	28	33	37	48	76
45	75	10	100.0	198	310	357	411	516	813
45	84	1	100.0	1	84	96	109	141	232
45	84	5	0.0	1	1416	1692	2002	2727	4568
45	84	12	0.0	1	79	88	99	118	163
45	84	14	0.0	1	14	16	18	23	36
45	88	1	100.0	17	16	17	19	22	30
45	88	7	0.0	240	376	433	500	627	988
46	26	9	100.0	11	17	19	22	28	45
46	29	9	100.0	5	7	9	10	13	20
46	49	9	100.0	35	55	64	74	93	146
46	57	9	100.0	8	12	14	16	21	33
46	59	9	100.0	16	25	29	34	42	67
46	61	9	100.0	11	18	21	25	31	50
46	63	9	100.0	7	10	12	14	18	28
46	65	9	100.0	6	9	10	12	15	24
46	68	9	100.0	18	29	34	39	49	78
46	75	9	100.0	10	16	18	21	26	42
47	26	9	100.0	11	17	19	23	29	47
47	32	5	0.0	158	280	320	366	469	771
47	44	5	0.0	35	62	71	82	105	172
47	45	9	100.0	6	9	11	13	16	26
47	47	5	0.0	8	15	17	19	25	41
47	56	9	100.0	10	15	18	21	28	44
47	57	9	100.0	10	16	19	22	28	45
47	59	9	100.0	17	28	33	39	50	78
47	63	9	100.0	21	32	38	44	56	88
47	66	9	100.0	8	12	14	17	21	35
49	14	5	0.0	8	18	21	25	32	54
49	28	5	0.0	7	17	20	24	32	53
49	37	5	0.0	10	22	27	32	41	69
49	39	6	0.0	5	12	15	18	23	38
49	40	6	0.0	54	85	94	103	126	188
49	47	6	0.0	70	111	122	135	165	245
49	49	6	0.0	538	886	985	1098	1352	2054

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
49	65	10	100.0	6	9	11	12	16	26
49	75	7	0.0	6	10	11	12	16	26
49	76	14	0.0	9	19	22	27	37	64
49	84	6	0.0	1	454	520	597	757	1195
49	88	1	100.0	9	9	9	9	11	14
49	102	5	0.0	1	391	454	526	675	1078
50	36	6	0.0	12	22	25	29	37	61
50	47	5	0.0	2023	3565	4091	4694	5985	9733
50	53	6	0.0	8	14	16	18	24	39
50	56	5	0.0	7	12	14	17	21	35
50	57	5	0.0	88	156	179	205	263	427
50	66	5	0.0	6	12	13	15	20	33
50	67	6	0.0	49	87	101	115	147	240
50	68	6	0.0	332	586	674	774	986	1606
50	71	6	0.0	164	290	334	383	489	796
50	71	14	0.0	62	91	109	128	166	279
50	72	6	0.0	92	164	189	217	277	452
50	72	14	0.0	582	856	1004	1180	1526	2541
50	73	6	0.0	880	1550	1779	2042	2603	4234
50	73	14	0.0	71	105	123	144	187	313
50	88	1	100.0	35	40	43	45	52	69
50	88	6	0.0	45	81	93	107	137	223
50	88	14	0.0	466	683	803	944	1219	2031
50	91	5	0.0	68	121	139	160	204	334
50	93	5	0.0	8	15	17	20	25	41
50	93	14	0.0	32	47	55	65	84	141
51	12	12	0.0	15	23	27	32	42	71
51	16	4	0.0	8	12	13	15	19	29
51	16	6	0.0	22	40	46	53	67	109
51	16	12	0.0	28	41	49	57	74	123
51	17	14	0.0	12	17	20	24	31	52
51	26	9	100.0	20	30	34	40	51	80
51	29	9	100.0	23	34	39	45	57	90
51	38	14	0.0	20	30	35	41	53	89
51	44	9	100.0	24	36	41	48	60	95
51	49	9	100.0	5	8	10	11	14	23
51	51	9	100.0	5	8	10	11	14	22
51	51	10	100.0	116	173	199	229	288	455
51	52	10	.0	22	33	39	45	56	89
51	59	9	.0	50	74	87	99	125	19

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
51	59	12	0.0	18	28	33	39	50	84
51	64	9	100.0	8	12	14	16	20	32
51	65	9	100.0	11	16	19	22	27	43
51	66	9	100.0	10	15	17	20	25	41
51	67	6	0.0	102	180	207	237	303	493
51	67	14	0.0	10	15	17	20	26	44
51	68	1	100.0	6	11	12	13	16	23
51	68	6	0.0	698	1231	1414	1622	2068	3364
51	68	9	100.0	59	90	102	119	149	236
51	68	11	0.0	8	14	17	20	27	47
51	68	14	0.0	376	550	647	761	984	1638
51	69	9	100.0	10	15	17	20	25	40
51	71	6	0.0	272	483	554	636	811	1321
51	71	11	0.0	49	86	104	126	166	288
51	71	14	0.0	664	973	1145	1343	1736	2890
51	72	6	0.0	7	13	14	17	21	35
51	72	14	0.0	59	86	102	119	154	258
51	73	1	100.0	24	32	35	39	47	66
51	73	6	0.0	1388	2446	2807	3221	4106	6678
51	73	10	100.0	20	30	35	40	50	80
51	73	14	0.0	738	1081	1270	1493	1926	3210
51	76	6	0.0	5	10	12	13	17	28
51	76	10	100.0	13	19	22	25	32	52
51	77	6	0.0	5	10	11	13	17	29
51	77	14	0.0	11	17	19	23	30	51
51	84	12	0.0	1	84	95	108	132	191
51	88	1	100.0	89	120	132	144	173	246
51	88	2	0.0	8	9	10	11	13	18
51	88	12	0.0	7	11	13	15	20	33
52	11	10	100.0	6	9	10	12	15	25
52	16	6	0.0	58	103	118	135	173	281
52	26	9	100.0	8	12	13	16	20	31
52	36	10	100.0	11	17	20	23	29	46
52	39	6	0.0	1137	2004	2300	2638	3364	5471
52	40	6	0.0	223	393	451	518	660	1075
52	44	12	0.0	19	28	32	38	50	83
52	50	6	0.0	453	799	916	1052	1341	2181
52	51	6	0.0	44	77	89	102	130	212
52	51	10	100.0	62	92	106	122	153	243
52	52	6	0.0	403	711	816	936	1194	1942

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
52	52	10	100.0	18	27	31	36	46	72
52	53	6	0.0	34	60	69	79	101	164
52	54	13	0.0	8	11	13	16	20	34
52	65	10	100.0	20	30	35	40	51	80
52	68	6	0.0	6	11	12	14	18	30
52	68	10	100.0	9	14	16	19	24	37
53	22	5	0.0	3774	6649	7631	8755	11163	18152
53	26	5	0.0	1014	1786	2050	2352	2999	4877
53	29	11	0.0	7	12	14	17	22	36
53	32	11	0.0	75	119	138	160	202	321
53	39	11	0.0	31	58	71	86	113	196
53	43	11	0.0	25	45	54	66	86	147
53	45	11	0.0	28	58	69	84	108	180
53	59	11	0.0	85	115	126	138	166	238
53	61	11	0.0	9	13	15	16	19	27
53	68	5	0.0	11	20	23	26	34	55
53	68	11	0.0	193	336	408	495	652	1128
53	73	5	0.0	82	144	166	190	243	395
53	73	11	0.0	11	21	27	33	45	80
53	88	1	100.0	25	34	37	41	49	70
53	88	11	0.0	102	201	252	315	422	754
54	29	1	100.0	10	13	15	16	20	30
54	30	10	100.0	9	13	15	17	21	33
54	32	15	100.0	21	30	34	38	47	71
54	36	1	100.0	34	44	50	55	68	100
54	39	10	100.0	18	26	29	34	42	64
54	43	1	100.0	157	203	226	254	307	452
54	43	7	0.0	13	19	21	24	30	[illegible]
54	44	1	100.0	71	92	103	116	141	207
54	44	7	0.0	7	11	12	14	18	27
54	45	1	100.0	82	107	119	134	163	239
54	45	7	0.0	6	8	9	11	13	21
54	47	9	100.0	19	29	33	37	46	72
54	84	1	100.0	1	112	119	126	139	170
54	86	9	100.0	1	57	61	65	74	96
54	91	1	100.0	39	52	58	65	80	116
55	44	1	100.0	5	7	8	9	11	17
55	45	1	100.0	9	12	13	15	18	27
56	44	4	0.0	13	27	32	39	50	84
57	43	1	[illegible]	36	41	42	47	54	72

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
57	44	1	100.0	42	47	52	54	64	85
57	45	1	100.0	54	61	66	71	81	109
57	91	1	100.0	34	37	38	42	50	67
58	5	6	0.0	19	42	50	59	77	127
58	12	6	0.0	8	19	22	26	34	57
58	26	7	0.0	23	32	34	36	43	61
58	36	9	100.0	29	40	43	46	54	77
58	39	11	0.0	88	167	203	247	325	561
58	84	11	0.0	1	107	122	140	178	282
58	91	1	100.0	20	21	22	26	32	42
58	91	11	0.0	5	10	13	16	21	37
58	93	11	0.0	70	138	173	217	290	519
59	9	14	0.0	18	25	28	31	36	55
59	13	9	100.0	6	8	9	10	11	17
59	13	14	0.0	8	10	11	13	15	22
59	16	10	100.0	21	29	32	35	42	61
59	16	15	100.0	68	88	99	112	139	213
59	20	10	100.0	7	10	10	11	14	20
59	24	10	100.0	28	37	40	44	53	76
59	29	12	0.0	68	92	101	110	133	191
59	32	10	100.0	36	48	52	57	69	100
59	34	10	100.0	6	8	9	10	12	17
59	35	12	0.0	10	15	16	18	22	32
59	39	12	0.0	39	55	60	66	79	115
59	43	12	0.0	15	21	22	25	30	43
59	44	1	100.0	10	12	14	15	18	25
59	44	7	0.0	8	10	11	12	15	22
59	44	10	100.0	47	62	69	74	90	128
59	44	12	0.0	37	51	57	63	75	109
59	44	14	0.0	6	9	10	11	13	19
59	45	1	100.0	7	9	10	11	13	18
59	45	9	100.0	9	12	14	15	18	26
59	45	10	100.0	9	13	14	15	18	26
59	45	12	0.0	15	21	23	25	31	45
59	47	12	0.0	7	9	10	11	14	19
59	51	14	0.0	10	14	16	18	21	31
59	84	9	100.0	1	37	47	59	86	170
59	84	12	0.0	1	22	25	29	34	48
59	91	10	100.0	12	15	17	19	22	32
59	93	5	0.0	5	9	11	12	15	24

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
59	93	10	100.0	8	9	10	10	15	22
59	93	12	0.0	8	12	12	14	17	25
59	93	14	0.0	10	15	16	18	22	32
59	95	12	0.0	1	73	86	102	135	235
59	96	12	0.0	1	150	164	181	217	283
60	26	10	100.0	11	15	16	18	21	31
60	42	10	100.0	11	15	16	18	21	31
60	43	10	100.0	10	14	15	16	20	28
60	44	1	100.0	11	14	15	17	21	29
60	44	10	100.0	22	29	32	34	41	59
60	45	1	100.0	9	10	11	13	15	22
60	91	1	100.0	10	12	13	14	17	24
60	93	10	100.0	31	40	43	49	58	83
61	29	12	0.0	7	10	11	12	14	20
61	39	12	0.0	16	23	25	27	33	48
61	43	1	100.0	9	12	13	14	16	24
61	44	1	100.0	170	207	226	242	286	395
61	45	1	100.0	194	238	256	278	328	454
61	91	1	100.0	92	110	121	133	157	219
61	93	12	0.0	8	13	14	16	19	28
62	10	12	0.0	10	15	17	19	24	36
62	91	1	100.0	7	8	9	9	11	15
63	36	1	100.0	67	74	78	83	95	125
63	43	1	100.0	26	30	32	34	39	53
63	44	7	0.0	33	42	47	52	64	94
63	45	1	100.0	47	56	60	66	77	107
64	36	1	100.0	17	19	20	22	25	33
64	42	1	100.0	7	8	8	8	10	13
64	43	1	100.0	243	269	284	299	344	453
64	45	1	100.0	22	24	25	27	31	41
65	5	10	100.0	10	13	14	15	18	26
65	6	10	100.0	8	10	11	12	15	21
65	7	10	100.0	9	11	12	13	16	22
65	8	6	0.0	5	12	13	16	20	32
65	8	7	0.0	34	43	47	51	61	86
65	8	10	100.0	16	22	25	28	33	49
65	12	9	100.0	8	13	15	18	23	37
65	12	10	100.0	18	22	24	26	31	45
65	13	10	100.0	81	104	113	123	146	206
65	13	12	0.0	97	142	160	181	223	[illegible]

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
65	24	10	100.0	22	29	31	34	40	57
65	26	7	0.0	30	39	42	46	55	78
65	26	10	100.0	118	151	165	179	213	301
65	29	10	100.0	104	133	145	158	187	264
65	30	10	100.0	20	26	28	31	36	52
65	32	10	100.0	9	11	13	14	17	24
65	35	10	100.0	261	334	363	395	469	661
65	39	10	100.0	126	161	174	191	226	319
65	41	1	100.0	21	24	25	27	32	43
65	41	10	100.0	128	164	178	194	230	324
65	42	10	100.0	110	141	153	166	198	279
65	43	1	100.0	21	24	26	28	33	44
65	43	10	100.0	149	191	207	225	268	378
65	44	10	100.0	10	13	14	16	19	27
65	45	1	100.0	39	46	49	52	61	82
65	45	10	100.0	58	75	81	89	105	148
65	48	10	100.0	21	27	29	32	38	53
65	49	10	100.0	40	52	56	61	73	102
65	51	9	100.0	14	18	19	21	25	35
65	52	10	100.0	26	33	36	39	46	65
65	91	1	100.0	16	18	20	21	24	33
65	93	10	100.0	46	60	65	70	84	118
66	8	6	0.0	5	12	14	16	20	33
66	12	11	0.0	114	153	171	189	229	336
66	13	11	0.0	10	14	16	18	22	34
66	25	6	0.0	8	18	20	24	30	48
66	26	9	100.0	14	18	19	21	25	35
66	26	10	100.0	9	12	13	15	17	25
66	26	11	0.0	168	251	283	319	393	593
66	39	9	100.0	62	80	87	95	113	159
66	39	10	100.0	9	13	14	14	18	25
66	45	1	100.0	14	17	18	19	22	30
66	47	5	0.0	1573	3295	3810	4406	5573	8911
66	52	10	100.0	9	11	12	14	16	23
66	52	11	0.0	31	46	54	63	81	136
66	82	1	100.0	1	82	96	111	143	227
66	84	1	100.0	1	170	211	259	371	740
66	84	5	0.0	1	221	258	301	390	629
66	93	5	0.0	35	75	86	100	126	202
66	93	6	0.0	26	56	65	75	95	152

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
66	100	12	0.0	1	10	11	12	14	18
67	25	6	0.0	29	60	70	81	103	164
67	44	1	100.0	7	9	9	10	11	16
67	45	1	100.0	7	8	8	9	10	14
67	84	1	100.0	1	46	56	67	94	179
68	6	4	0.0	26	35	39	42	50	71
68	6	9	100.0	10	15	17	20	26	41
68	7	10	100.0	53	81	94	110	139	222
68	8	14	0.0	9	16	20	25	32	56
68	12	10	100.0	14	22	25	30	38	61
68	12	12	0.0	7	13	17	20	26	47
68	13	10	100.0	24	37	43	51	65	104
68	19	10	100.0	154	237	275	320	404	648
68	26	9	100.0	79	120	141	163	207	332
68	26	10	100.0	14	23	26	30	39	62
68	26	15	100.0	15	22	25	29	36	56
68	29	9	100.0	5	8	9	11	14	23
68	29	10	100.0	71	109	127	147	186	298
68	30	10	100.0	15	23	28	32	41	66
68	32	10	100.0	11	17	20	23	30	49
68	35	9	100.0	29	46	53	61	78	125
68	35	10	100.0	53	81	95	110	139	224
68	36	10	100.0	40	62	72	83	106	169
68	39	10	100.0	54	84	98	114	144	231
68	40	5	0.0	11	18	20	22	27	40
68	47	9	100.0	5	8	9	11	14	23
68	50	9	100.0	7	11	13	15	19	31
68	91	1	100.0	19	20	20	22	25	33
68	91	10	100.0	5	8	9	11	14	22
68	93	14	0.0	9	16	20	24	32	56
69	12	10	100.0	6	10	11	13	17	29
69	13	5	0.0	8	11	12	12	13	16
69	13	10	100.0	11	18	21	25	32	53
69	26	9	100.0	25	40	47	55	70	116
69	32	10	100.0	32	49	58	68	88	144
69	35	9	100.0	44	68	80	93	120	197
69	43	1	100.0	49	52	54	57	65	85
69	43	10	100.0	55	86	101	118	151	250
69	45	1	100.0	29	31	32	34	39	51
69	47	5	0.0	6	9	10	10	10	12

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
69	48	10	100.0	40	63	73	86	111	182
69	90	5	0.0	97	142	147	150	164	195
69	91	5	0.0	11	16	17	18	19	23
69	92	5	0.0	9	14	15	15	17	20
69	93	5	0.0	37	51	52	53	56	65
69	93	10	100.0	9	14	16	19	24	40
71	30	10	100.0	18	28	33	39	50	81
71	43	10	100.0	12	19	22	26	33	53
71	49	10	100.0	8	13	15	18	23	38
71	91	1	100.0	23	28	29	31	37	52
72	20	9	100.0	15	24	29	35	45	76
72	32	10	100.0	11	19	24	29	38	67
72	32	15	100.0	13	18	21	23	29	44
72	48	10	100.0	6	11	13	15	20	34
72	89	9	100.0	36	56	65	76	97	155
72	91	1	100.0	9	11	12	14	17	24
72	91	10	100.0	7	11	14	16	21	36
72	91	15	100.0	9	14	16	18	23	37
73	5	4	0.0	6	9	10	10	13	18
73	5	10	100.0	11	20	24	29	39	68
73	6	4	0.0	317	424	463	505	600	849
73	6	6	0.0	9	11	12	12	12	14
73	6	10	100.0	59	103	126	153	201	350
73	6	12	0.0	45	86	108	134	179	320
73	7	6	0.0	10	12	12	12	13	15
73	7	10	100.0	35	62	75	91	121	210
73	7	12	0.0	10	19	23	29	39	70
73	8	4	0.0	10	13	15	17	19	28
73	8	9	100.0	24	42	51	62	81	142
73	8	10	100.0	45	79	95	116	153	266
73	8	12	0.0	17	31	40	50	67	119
73	9	9	100.0	52	92	112	136	179	312
73	9	10	100.0	46	80	98	119	157	272
73	9	12	0.0	15	29	36	46	61	109
73	10	4	0.0	10	14	15	17	20	29
73	10	6	0.0	8	11	11	11	12	13
73	10	12	0.0	11	22	27	34	46	82
73	11	4	0.0	35	48	52	57	68	96
73	11	9	100.0	26	45	55	67	89	154
73	11	10	100.0	167	293	356	432	569	988

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
73	11	12	0.0	20	38	48	60	80	142
73	12	4	0.0	41	57	63	71	87	131
73	12	6	0.0	56	70	70	71	76	86
73	12	9	100.0	32	57	70	84	111	194
73	12	10	100.0	306	538	652	792	1045	1816
73	12	12	0.0	181	344	429	534	714	1271
73	13	4	0.0	89	125	140	158	194	295
73	13	9	100.0	6	11	13	16	22	38
73	13	10	100.0	25	44	54	65	86	150
73	14	9	100.0	623	1095	1329	1613	2126	3693
73	14	10	100.0	20	37	45	54	73	129
73	16	4	0.0	163	247	279	315	389	590
73	16	9	100.0	200	351	426	517	682	1184
73	16	10	100.0	113	199	242	294	387	673
73	16	12	0.0	13	26	32	40	54	96
73	16	15	100.0	22	29	32	36	45	69
73	17	4	0.0	84	120	135	152	188	289
73	17	9	100.0	210	368	446	542	715	1241
73	18	4	0.0	8	12	13	15	19	29
73	18	10	100.0	173	303	368	447	590	1024
73	19	9	100.0	35	61	74	90	119	207
73	20	6	0.0	19	24	24	24	26	30
73	20	9	100.0	91	160	194	235	310	539
73	20	10	100.0	314	551	669	812	1071	1859
73	22	10	100.0	5	9	11	13	17	30
73	23	4	0.0	124	192	222	258	327	525
73	23	9	100.0	81	143	174	212	280	485
73	23	10	100.0	44	79	96	117	155	271
73	25	4	0.0	33	47	52	58	71	106
73	25	6	0.0	15	19	19	19	20	23
73	25	9	100.0	16	28	34	41	54	96
73	25	12	0.0	13	25	32	39	53	94
73	26	4	0.0	269	403	455	513	631	955
73	26	7	0.0	6	12	14	17	23	40
73	26	9	100.0	459	805	978	1187	1565	2717
73	26	10	100.0	114	200	243	295	389	676
73	28	9	100.0	30	54	65	79	104	182
73	29	9	100.0	12	21	26	31	42	73
73	29	10	100.0	230	404	491	596	785	1364
73	30	9	[illegible]	53	93	113	138	182	316

(Continued)

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AD-A163 256 REEVALUATION OF THE OLIVER LOCK REPLACEMENT PROJECT APPENDIX B ECONOMICS(U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS HYDRA.. 2/2

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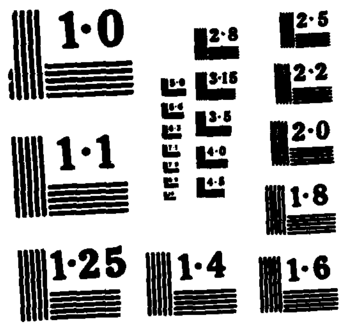

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
73	11	12	0.0	20	38	48	60	80	142
73	12	4	0.0	41	57	63	71	87	131
73	12	6	0.0	56	70	70	71	76	86
73	12	9	100.0	32	57	70	84	111	194
73	12	10	100.0	306	538	652	792	1045	1816
73	12	12	0.0	181	344	429	534	714	1271
73	13	4	0.0	89	125	140	158	194	295
73	13	9	100.0	6	11	13	16	22	38
73	13	10	100.0	25	44	54	65	86	150
73	14	9	100.0	623	1095	1329	1613	2126	3693
73	14	10	100.0	20	37	45	54	73	129
73	16	4	0.0	163	247	279	315	389	590
73	16	9	100.0	200	351	426	517	682	1184
73	16	10	100.0	113	199	242	294	387	673
73	16	12	0.0	13	26	32	40	54	96
73	16	15	100.0	22	29	32	36	45	69
73	17	4	0.0	84	120	135	152	188	289
73	17	9	100.0	210	368	446	542	715	1241
73	18	4	0.0	8	12	13	15	19	29
73	18	10	100.0	173	303	368	447	590	1024
73	19	9	100.0	35	61	74	90	119	207
73	20	6	0.0	19	24	24	24	26	30
73	20	9	100.0	91	160	194	235	310	539
73	20	10	100.0	314	551	669	812	1071	1859
73	22	10	100.0	5	9	11	13	17	30
73	23	4	0.0	124	192	222	258	327	525
73	23	9	100.0	81	143	174	212	280	485
73	23	10	100.0	44	79	96	117	155	271
73	25	4	0.0	33	47	52	58	71	106
73	25	6	0.0	15	19	19	19	20	23
73	25	9	100.0	16	28	34	41	54	96
73	25	12	0.0	13	25	32	39	53	94
73	26	4	0.0	269	403	455	513	631	955
73	26	7	0.0	6	12	14	17	23	40
73	26	9	100.0	459	805	978	1187	1565	2717
73	26	10	100.0	114	200	243	295	389	676
73	28	9	100.0	30	54	65	79	104	182
73	29	9	100.0	12	21	26	31	42	73
73	29	10	100.0	230	404	491	596	785	1364
73	30	9	[illegible] 0	53	93	113	138	182	316

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
73	103	9	100.0	8	15	19	23	30	52
73	105	9	100.0	38	68	82	100	132	230
74	6	6	0.0	8	9	9	8	9	10
74	7	6	0.0	14	15	15	15	15	17
74	8	6	0.0	7	7	7	7	7	8
74	9	6	0.0	12	13	13	13	14	15
74	9	9	100.0	9	15	18	22	28	47
74	10	6	0.0	7	7	7	7	7	8
74	11	9	100.0	54	90	107	127	164	271
74	12	6	0.0	60	65	64	63	66	74
74	12	12	0.0	4	11	15	19	26	47
74	20	9	100.0	50	97	115	139	179	299
74	23	9	100.0	49	83	99	117	151	250
74	25	6	0.0	9	10	10	10	10	11
74	26	6	0.0	9	10	10	10	10	11
74	32	9	100.0	433	727	862	1025	1319	2183
74	32	12	0.0	11	24	30	37	51	92
74	34	4	0.0	73	116	133	155	196	312
74	34	9	100.0	219	369	439	520	669	1108
74	34	14	0.0	6	12	15	18	25	46
74	38	6	0.0	8	8	8	8	9	10
74	39	9	100.0	9	17	20	25	32	52
74	40	12	0.0	4	11	15	19	26	48
74	44	9	100.0	73	122	144	171	219	364
74	49	9	100.0	6	11	13	16	21	35
74	91	9	100.0	23	39	47	56	72	120
74	91	10	100.0	6	10	12	14	18	31
74	91	15	100.0	21	30	35	40	51	81
74	98	6	0.0	8	8	8	8	8	10
75	5	10	100.0	38	64	76	90	116	194
75	6	10	100.0	18	32	39	45	58	97
75	7	10	100.0	186	309	367	435	560	928
75	8	9	100.0	31	54	63	77	98	164
75	8	10	100.0	162	272	324	384	492	819
75	9	9	100.0	34	57	68	80	103	171
75	9	10	100.0	6	12	13	17	22	37
75	9	12	0.0	13	29	36	45	62	112
75	10	10	100.0	10	17	20	24	31	52
75	10	12	0.0	5	12	15	19	26	48
75	11	9	0.0	210	346	408	484	623	1031

(Continued)

Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
75	11	10	100.0	26	44	53	63	80	136
75	12	9	100.0	33	56	66	80	102	169
75	12	10	100.0	47	79	94	111	145	240
75	12	12	0.0	3	8	10	12	18	32
75	13	10	100.0	4	7	9	11	14	24
75	14	9	100.0	27	48	55	67	85	143
75	15	9	100.0	12	20	23	28	36	60
75	16	9	100.0	40	69	81	96	124	206
75	16	10	100.0	12	20	23	28	36	59
75	16	12	0.0	5	12	15	19	25	46
75	16	15	100.0	11	15	17	19	23	36
75	19	9	100.0	8	14	16	21	27	45
75	19	10	100.0	16	26	31	37	48	79
75	20	9	100.0	340	567	672	796	1024	1696
75	20	10	100.0	52	87	102	121	156	260
75	23	9	100.0	115	193	230	272	351	584
75	23	10	100.0	43	73	86	102	131	219
75	24	10	100.0	7	12	14	17	22	36
75	26	9	100.0	315	528	625	740	952	1580
75	26	10	100.0	33	55	65	78	101	168
75	28	10	100.0	14	24	28	34	44	74
75	29	10	100.0	75	125	148	175	227	375
75	30	9	100.0	210	351	416	493	635	1052
75	30	10	100.0	6	10	11	14	18	30
75	32	10	100.0	12	21	24	29	38	62
75	36	9	100.0	39	66	79	93	119	198
75	36	10	100.0	5	9	10	12	16	27
75	39	9	100.0	84	142	168	200	257	427
75	39	10	100.0	23	39	45	54	70	118
75	41	9	100.0	12	20	24	28	37	61
75	41	10	100 0	5	9	11	13	17	28
75	43	9	100.0	8	13	16	19	25	41
75	43	10	100.0	26	44	52	63	81	135
75	45	9	100.0	644	1073	1272	1506	1937	3208
75	45	10	100.0	17	29	35	41	53	88
75	46	9	100.0	15	26	30	37	46	78
75	47	10	100.0	6	10	12	15	19	32
75	49	10	100.0	21	35	42	50	65	107
75	51	9	100.0	219	366	433	514	660	1094
75	51	15	100.0	39	59	68	78	98	155

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
75	89	9	100.0	22	38	46	55	71	119
75	89	10	100.0	118	197	234	277	358	593
75	89	14	0.0	7	16	20	25	35	63
75	90	9	100.0	153	255	302	358	462	765
75	90	10	100.0	24	41	49	57	74	124
75	91	9	100.0	372	622	736	873	1123	1862
75	91	10	100.0	263	441	522	620	799	1323
75	91	12	0.0	4	12	15	20	28	51
75	93	4	0.0	5	10	12	17	22	40
75	93	10	100.0	25	43	51	61	78	129
75	98	10	100.0	19	32	37	45	59	98
75	100	9	100.0	73	121	143	170	219	363
75	103	10	100.0	21	35	42	50	65	108
75	104	10	100.0	23	39	47	56	72	119
76	5	12	0.0	17	33	41	51	68	121
76	8	9	100.0	36	58	68	82	106	176
76	8	10	100.0	83	133	158	188	243	410
76	9	9	100.0	29	53	64	79	105	184
76	9	10	100.0	72	122	147	178	233	397
76	11	9	100.0	12	19	22	26	34	56
76	11	10	100.0	25	40	48	56	72	119
76	12	9	100.0	6	9	11	13	17	29
76	12	10	100.0	34	54	65	75	98	163
76	13	10	100.0	14	25	31	38	50	88
76	14	9	100.0	40	72	86	105	137	238
76	14	10	100.0	21	38	46	55	72	126
76	16	9	100.0	6	10	11	13	17	29
76	19	9	100.0	195	304	357	421	541	892
76	19	10	100.0	9	13	17	19	26	42
76	20	9	100.0	14	23	27	32	41	68
76	22	9	100.0	9	17	21	26	35	61
76	23	9	100.0	12	19	24	27	37	63
76	26	6	0.0	27	25	24	24	25	27
76	26	9	100.0	50	78	92	109	142	234
76	26	10	100.0	79	122	145	171	220	364
76	32	10	100.0	49	81	96	114	148	247
76	34	10	100.0	9	16	20	25	33	58
76	39	9	100.0	6	9	12	13	17	29
76	39	12	0.0	12	24	29	36	49	88
76	41	10	100.0	7	13	15	18	24	40

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PF	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
76	43	12	0.0	5	9	12	15	20	38
76	49	14	0.0	73	153	190	240	322	575
76	52	10	100.0	6	9	11	13	17	28
76	89	9	100.0	7	12	15	17	23	40
76	89	10	100.0	70	111	131	155	200	333
76	89	14	0.0	6	12	14	18	25	46
76	90	9	100.0	26	40	47	57	73	122
76	90	10	100.0	200	311	365	430	554	913
76	91	7	0.0	9	17	20	25	34	61
76	91	9	100.0	82	148	180	220	290	505
76	91	10	100.0	268	417	492	580	747	1233
76	91	15	100.0	9	13	15	18	23	36
76	93	10	100.0	8	15	18	23	30	54
76	98	10	100.0	11	18	22	25	33	58
76	100	9	100.0	8	14	17	20	27	48
76	103	10	100.0	16	24	29	34	45	74
77	1	6	0.0	20	28	28	28	31	33
77	7	6	0.0	107	150	152	154	163	180
77	8	6	0.0	60	84	86	86	92	102
77	10	6	0.0	5	7	7	7	8	9
77	16	6	0.0	56	79	81	82	86	96
77	19	6	0.0	48	67	68	69	74	83
77	20	6	0.0	16	22	22	23	24	27
77	23	6	0.0	21	31	31	31	33	36
77	25	6	0.0	79	110	111	113	119	133
77	26	6	0.0	410	569	577	584	616	687
77	29	6	0.0	204	284	289	292	308	342
77	30	10	100.0	63	127	156	193	255	446
77	32	6	0.0	92	129	130	133	140	156
77	32	10	100.0	25	50	62	76	101	176
77	36	6	0.0	46	64	64	66	69	77
77	36	15	100.0	29	42	47	54	66	100
77	39	6	0.0	35	50	51	51	54	60
77	41	6	0.0	6	9	10	10	10	11
77	42	6	0.0	100	138	140	142	150	167
77	46	6	0.0	138	193	196	198	211	234
77	47	6	0.0	7	10	10	10	11	12
77	48	6	0.0	6	8	8	8	9	10
77	49	6	0.0	6	9	9	10	10	11
77	51	6	0.0	338	469	475	482	509	567

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
77	51	9	100.0	69	140	172	212	280	491
77	52	10	100.0	47	96	118	145	192	337
77	53	6	0.0	5	8	8	8	8	9
77	90	10	100.0	5	11	14	17	22	39
77	90	15	100.0	10	12	15	16	22	35
77	91	1	100.0	9	12	13	14	17	25
77	91	6	0.0	68	95	96	97	102	114
77	93	14	0.0	19	46	60	75	103	185
77	98	9	100.0	19	39	48	59	79	138
77	105	6	0.0	122	171	173	175	186	206
80	95	9	100.0	1	223	266	315	422	722
81	96	6	0.0	1	35	41	49	64	112
8.	47	9	100.0	1	32	35	37	42	55
82	88	10	100.0	769	1144	1325	1536	1937	3082
83	98	10	100.0	6	8	10	11	14	23
83	98	15	100.0	38	53	60	69	86	135
84	9	9	100.0	1	217	264	323	446	830
84	12	6	0.0	1	80	94	110	146	247
84	15	6	0.0	1	49	56	65	83	133
84	20	6	0.0	1	107	123	141	181	289
84	20	9	100.0	1	58	68	80	107	181
84	23	6	0.0	1	107	123	141	181	289
84	26	6	0.0	1	37	45	53	71	122
84	26	6	0.0	1	36	42	48	61	99
84	26	12	0.0	1	19	21	23	26	35
84	29	3	0.0	1	15	17	19	24	37
84	32	6	0.0	1	242	920	988	999	999
84	41	4	0.0	1	95	104	114	134	184
84	41	9	100.0	1	17	20	23	29	45
84	44	6	0.0	1	447	540	652	890	1555
84	44	9	100.0	1	108	131	157	217	401
84	45	2	0.0	1	63	74	86	113	190
84	45	4	0.0	1	13	14	16	19	28
84	45	9	100.0	1	108	131	157	217	401
84	45	12	0.0	1	17	19	22	28	43
84	49	4	0.0	1	51	58	65	79	111
84	49	6	0.0	1	340	382	428	519	730
84	51	4	0.0	1	84	95	108	132	191
84	51	9	100.0	1	109	132	161	222	409
84	54	3	0	1	15	17	20	25	40

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
84	59	8	0.0	1	38	44	51	65	107
84	59	9	100.0	1	369	454	555	772	1441
84	59	12	0.0	1	21	23	25	29	40
84	95	4	0.0	1	23	25	27	31	41
84	95	6	0.0	1	65	70	75	86	114
84	98	4	0.0	3037	4650	5434	6351	8149	13411
84	98	10	100.0	95	136	157	180	227	362
84	98	12	0.0	44	86	106	130	172	301
84	98	15	100.0	253	348	396	452	566	886
84	99	4	0.0	10	16	18	21	28	46
84	100	15	100.0	22	31	35	40	50	79
84	102	9	100.0	18	26	29	34	43	69
84	104	9	100.0	38	54	62	72	91	144
84	104	10	100.0	13	19	21	25	31	51
84	105	6	0.0	84	233	279	333	430	718
86	26	2	0.0	1	33	38	42	55	89
86	44	10	100.0	1	37	43	49	62	99
86	45	9	100.0	1	66	69	74	83	105
86	57	2	0.0	1	19	22	26	34	57
86	59	8	0.0	1	38	44	51	65	107
86	61	2	0.0	1	16	19	21	27	27
86	95	9	100.0	1	45	47	50	57	72
86	105	3	0.0	302	475	551	638	807	1293
88	5	2	0.0	5	8	11	12	16	26
88	5	10	100.0	22	37	45	54	71	124
88	5	12	0.0	9	19	24	30	41	73
88	6	4	0.0	21	28	32	34	41	58
88	6	5	0.0	10	12	12	12	12	14
88	6	10	100.0	120	196	238	287	377	652
88	6	12	0.0	4	9	11	14	19	34
88	7	10	100.0	102	167	202	243	320	554
88	8	10	100.0	8	13	17	20	26	46
88	9	9	100.0	23	38	46	55	73	126
88	9	10	100.0	23	37	45	55	72	125
88	10	12	0.0	49	98	123	154	207	369
88	11	10	100.0	34	56	67	81	107	185
88	11	12	0.0	5	11	14	18	24	45
88	12	4	0.0	8	12	13	15	19	29
88	12	6	0.0	44	53	52	52	55	62
88	12	9	100.0	8	13	16	19	26	47

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
88	12	10	100.0	91	153	184	222	293	509
88	12	12	0.0	129	257	322	403	539	965
88	13	4	0.0	18	26	29	33	42	64
88	13	10	100.0	45	74	89	107	141	244
88	14	6	0.0	37	44	44	44	46	51
88	14	9	100.0	16	26	32	39	51	89
88	14	12	0.0	9	20	26	32	43	79
88	16	2	0.0	7	10	12	15	19	31
88	16	4	0.0	32	50	57	63	78	121
88	16	9	100.0	79	130	157	189	249	430
88	16	12	0.0	16	32	41	51	68	122
88	17	12	0.0	14	29	37	46	63	113
88	19	9	100.0	7	11	14	17	22	39
88	20	6	0.0	44	52	52	52	55	61
88	20	9	100.0	76	125	152	183	241	417
88	22	9	100.0	7	13	15	18	24	43
88	23	6	0.0	28	33	33	33	35	39
88	23	9	100.0	77	128	155	189	248	431
88	23	15	100.0	20	34	40	46	58	92
88	24	10	100.0	12	20	24	29	38	66
88	25	6	0.0	12	15	15	15	16	17
88	25	12	0.0	6	13	17	21	29	53
88	26	4	0.0	12	18	21	22	29	43
88	26	6	0.0	43	50	50	50	54	59
88	26	7	0.0	50	82	98	119	158	272
88	26	8	0.0	6	10	11	12	15	23
88	26	9	100.0	254	420	506	612	807	1396
88	26	10	100.0	55	91	109	132	173	301
88	26	12	0.0	147	291	365	457	612	1093
88	28	12	0.0	4	9	11	14	19	35
88	29	7	0.0	9	16	19	23	31	53
88	29	9	100.0	29	46	56	69	91	157
88	29	12	0.0	35	69	86	108	146	261
88	30	9	100.0	8	13	16	20	26	45
88	30	10	100.0	647	1062	1281	1545	2033	3516
88	31	10	100.0	4	8	9	12	15	28
88	32	9	100.0	12	20	24	30	40	69
88	32	10	100.0	191	315	380	461	607	1050
88	32	15	100.0	81	117	131	148	182	275
88	34	10	[illegible]	14	24	29	36	47	87

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
88	35	9	100.0	64	105	128	154	203	351
88	35	10	100.0	85	139	168	203	267	462
88	35	12	0.0	8	18	23	29	38	69
88	36	9	100.0	23	38	46	56	73	128
88	36	10	100.0	33	55	67	80	106	183
88	36	12	0.0	5	11	14	18	24	43
88	36	15	100.0	254	365	410	460	566	854
88	39	7	0.0	7	12	15	18	24	42
88	39	9	100.0	75	122	148	179	236	408
88	39	10	100.0	53	87	105	127	167	290
88	39	12	0.0	118	240	301	378	506	907
88	39	14	0.0	6	13	16	21	28	51
88	41	7	0.0	5	8	10	12	16	29
88	41	9	100.0	5	9	11	13	18	31
88	41	10	100.0	7	11	14	17	22	38
88	43	7	0.0	20	33	40	48	64	111
88	43	10	100.0	43	70	85	102	134	233
88	43	12	0.0	12	24	31	39	54	96
88	44	1	100.0	18	21	23	25	30	[illegible]
88	44	7	0.0	50	85	102	124	163	283
88	44	9	100.0	19	32	38	46	61	106
88	45	7	0.0	12	20	24	29	38	68
98	45	9	100.0	16	28	33	40	53	94
88	45	10	100.0	9	16	19	23	31	53
88	47	10	100.0	115	189	229	275	363	628
88	48	10	100.0	43	71	86	104	137	237
88	49	4	0.0	24	45	55	67	89	153
88	49	10	100.0	5	9	11	13	18	31
88	49	12	0.0	13	27	34	43	57	104
88	50	9	100.0	27	45	54	65	86	148
88	52	6	0.0	6	7	7	7	7	8
88	52	10	100.0	423	694	836	1010	1329	2296
88	52	12	0.0	10	21	27	35	46	84
88	82	10	100.0	25	40	47	54	69	110
88	82	11	0.0	24	43	54	65	86	150
88	88	1	100.0	81	95	101	111	131	181
88	88	6	0.0	2154	2526	2524	2522	2657	2949
88	88	7	0.0	34	59	71	89	117	206
88	88	9	100.0	1345	2207	2661	3212	4226	7311
88	88	10	100.0	6619	10847	13086	15777	20759	35896

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
88	88	11	0.0	6	14	18	23	31	57
88	88	12	0.0	24	50	63	80	107	197
88	88	14	0.0	194	306	483	605	811	1451
88	88	15	100.0	4395	7202	8684	10477	13782	23830
88	89	9	100.0	49	80	95	116	153	267
88	89	10	100.0	314	516	624	752	992	1717
88	90	5	0.0	132	155	155	155	163	181
88	90	9	100.0	71	116	140	169	222	385
88	90	10	100.0	108	179	215	261	343	593
88	90	12	0.0	6	13	16	22	29	53
88	90	15	100.0	25	33	38	44	55	88
88	91	1	100.0	34	41	44	47	58	82
88	91	2	0.0	9	14	17	20	25	40
88	91	6	0.0	47	55	55	55	58	64
88	91	7	0.0	7	11	13	16	22	38
88	91	8	0.0	12	23	29	35	47	82
88	91	9	100.0	155	255	311	375	493	856
88	91	10	100.0	856	1404	1695	2043	2691	4653
88	91	12	0.0	61	120	151	190	255	455
88	91	14	0.0	7	15	20	25	33	61
88	91	15	100.0	34	51	58	67	86	139
88	93	4	0.0	9	19	23	30	41	74
88	93	6	0.0	7	8	8	8	8	9
88	93	10	100.0	215	358	430	524	690	1204
88	93	12	0.0	7	15	18	24	32	59
88	93	15	100.0	5	9	10	13	17	29
88	98	9	100.0	16	26	32	39	52	89
88	98	12	0.0	20	41	52	64	87	157
88	100	9	100.0	5	9	10	13	17	29
88	103	9	100.0	10	16	20	24	32	55
88	105	10	100.0	16	27	33	39	52	90
89	88	1	100.0	23	28	32	35	43	61
89	88	6	0.0	39	75	87	99	120	177
89	88	7	0.0	6	8	9	11	14	22
89	88	8	0.0	110	216	271	340	454	812
90	75	15	100.0	8	13	16	19	24	41
90	76	14	0.0	6	12	15	18	23	41
90	88	1	100.0	41	50	56	61	74	105
90	88	6	0.0	97	184	211	243	294	430
90	88	7	0.0	21	27	33	37	47	75

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
90	88	10	100.0	10	13	16	17	23	36
91	26	10	100.0	360	515	592	681	860	1365
91	29	3	0.0	12	19	22	26	33	52
91	30	10	100.0	73	105	121	139	176	279
91	32	9	100.0	39	57	65	75	95	152
91	36	15	100.0	24	35	39	44	54	82
91	39	9	100.0	35	51	60	68	86	138
91	44	9	100.0	13	19	22	25	31	50
91	45	9	100.0	54	79	90	103	131	209
91	51	9	100.0	24	35	40	46	58	92
91	52	10	100.0	6	9	10	12	15	24
91	54	3	0.0	11	19	22	26	32	52
91	54	10	100.0	59	85	98	112	142	225
91	58	4	0.0	14	20	22	24	29	43
91	65	4	0.0	8	12	14	16	19	29
91	65	10	100.0	90	128	148	170	215	341
91	65	15	100.0	6	7	8	9	10	15
91	66	10	100.0	12	16	19	22	28	45
91	68	5	0.0	31	37	37	37	39	43
91	68	9	100.0	31	44	51	59	74	118
91	68	15	100.0	523	801	931	1082	1369	2191
91	69	3	0.0	9	14	17	19	24	39
91	71	9	100.0	31	45	53	61	77	124
91	71	10	100.0	5	8	9	11	14	22
91	72	15	100.0	76	122	147	175	227	383
91	73	10	100.0	60	84	98	112	142	227
91	74	9	100.0	26	39	44	50	65	104
91	74	10	100.0	6	8	10	11	14	23
91	75	9	100.0	33	47	54	62	79	126
91	75	10	100.0	496	712	820	945	1192	1895
91	75	14	0.0	5	10	13	18	24	44
91	75	15	100.0	264	442	524	621	798	1323
91	76	10	100.0	241	344	398	458	576	917
91	76	11	0.0	8	17	21	27	36	64
91	76	15	100.0	869	1357	1598	1881	2419	3996
91	77	10	100.0	6	9	10	12	16	26
91	77	11	0.0	3	8	12	14	19	37
91	77	15	100.0	151	258	311	370	499	867
91	88	1	100.0	31	30	31	34	34	54
91	88	2	0.0	4	9	10	13	16	29

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
91	88	5	0.0	7	20	24	29	37	63
91	88	6	0.0	10	32	39	45	60	102
91	88	7	0.0	35	51	58	68	85	137
91	88	8	0.0	15	30	37	47	63	114
91	88	9	100.0	13	22	26	32	42	72
91	88	10	100.0	686	981	1130	1300	1642	2607
91	88	12	0.0	7	15	18	23	30	54
91	88	14	0.0	4	11	16	19	26	47
91	88	15	100.0	635	1042	1257	1516	1994	3448
92	26	10	100.0	13	18	21	24	31	49
92	68	10	100.0	22	31	36	41	52	83
92	70	9	100.0	62	89	103	118	149	237
92	71	9	100.0	35	51	59	68	86	137
92	72	9	100.0	47	68	78	90	113	180
92	74	9	100.0	20	30	34	38	49	79
92	77	9	100.0	37	52	60	70	89	141
92	89	10	100.0	29	42	49	56	71	113
93	12	4	0.0	12	17	20	21	26	39
93	12	12	0.0	23	44	57	71	95	170
93	13	4	0.0	69	98	110	124	152	231
93	16	4	0.0	72	109	123	139	172	261
93	25	4	0.0	5	7	8	9	11	17
93	26	4	0.0	11	16	18	20	25	38
93	26	9	100.0	32	53	64	77	101	175
93	32	9	100.0	48	79	95	115	152	264
93	32	10	100.0	6	11	14	18	24	42
93	40	4	0.0	7	13	16	20	26	46
93	49	4	0.0	17	33	41	49	65	113
93	51	6	0.0	6	7	7	7	8	9
93	59	6	0.0	19	22	22	22	24	26
93	59	7	0.0	10	17	21	25	33	58
93	59	12	0.0	3	8	11	14	19	34
93	60	6	0.0	29	34	34	34	36	40
93	60	9	100.0	15	24	29	35	46	81
93	65	4	0.0	23	34	39	44	54	82
93	65	9	100.0	5	8	9	11	15	27
93	66	9	100.0	5	8	9	11	15	27
93	68	10	100.0	6	9	11	14	19	33
93	69	11	0.0	53	94	113	135	175	295
93	72	6	0.0	6	7	7	7	8	

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
93	72	11	0.0	7	14	18	22	30	54
93	72	14	0.0	36	69	88	110	147	265
93	73	3	0.0	371	583	677	783	993	1589
93	73	9	100.0	10	16	19	23	31	54
93	73	11	0.0	6	12	16	20	27	48
93	73	14	0.0	38	73	92	117	156	282
93	75	11	0.0	45	100	125	156	209	377
93	76	6	0.0	10	11	11	11	12	13
93	76	9	100.0	5	8	9	11	15	27
93	76	10	100.0	6	9	11	14	18	32
93	76	11	0.0	4	9	11	15	20	36
93	76	14	0.0	42	83	105	131	176	315
93	77	3	0.0	667	1051	1219	1412	1790	2868
93	77	6	0.0	214	255	254	253	266	296
93	77	11	0.0	88	191	242	309	412	743
93	88	3	0.0	593	932	1079	1252	1587	2540
93	88	6	0.0	32	37	37	37	39	43
93	88	10	100.0	64	107	128	156	208	359
93	88	14	0.0	113	223	280	350	468	838
93	88	15	100.0	571	936	1131	1362	1791	3100
95	84	9	100.0	1	24	31	39	56	114
95	88	9	100.0	1	19	23	28	38	71
96	82	8	0.0	1	369	436	512	672	1114
96	84	1	100.0	1	340	393	456	601	1046
96	84	8	0.0	1	311	364	427	555	895
96	84	12	0.0	1	55	59	63	73	96
98	7	14	0.0	14	21	25	29	37	61
98	73	4	0.0	5	10	13	17	22	40
98	73	10	100.0	8	12	14	16	20	33
98	74	9	100.0	25	36	40	47	58	93
98	75	12	0.0	22	35	41	47	61	102
98	75	14	0.0	199	308	361	421	541	892
98	76	12	0.0	12	19	22	26	33	56
98	82	5	0.0	5	13	16	13	24	41
98	83	5	0.0	169	409	482	398	731	1215
98	83	10	100.0	31	43	49	56	70	110
98	84	5	0.0	1735	4187	4928	4067	7477	12422
98	84	10	100.0	114	157	178	203	255	399
98	84	11	0.0	72	140	173	212	281	491
98	84	15	100.0	8	12	14	16	20	32

(Continued)

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Table 1 (Continued)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
98	88	5	0.0	22	55	64	53	98	163
98	88	10	100.0	6	8	9	10	13	21
98	88	12	0.0	14	22	25	30	38	63
98	98	5	0.0	11	27	32	26	48	81
98	98	10	100.0	25	35	39	45	56	89
98	102	5	0.0	731	1764	2076	1714	3151	5234
98	103	5	0.0	17	41	49	40	74	124
98	104	10	100.0	14	19	22	25	31	49
98	105	5	0.0	1866	4502	5299	4373	8040	13357
98	105	10	100.0	7	9	11	12	16	25
99	83	5	0.0	114	275	324	268	492	818
99	84	5	0.0	1810	4369	5142	4244	7803	12962
99	88	5	0.0	9	23	27	23	42	70
99	98	5	0.0	5	13	15	13	24	40
99	102	5	0.0	6	15	18	15	28	46
99	104	5	0.0	7	17	21	17	31	53
99	105	5	0.0	234	566	667	550	1012	1681
100	29	9	100.0	1	13	14	16	19	26
100	44	10	100.0	1	60	69	78	100	161
100	57	9	100.0	1	12	13	15	18	25
100	66	9	100.0	1	12	13	14	17	23
100	83	5	0.0	17	41	49	40	74	124
100	84	1	100.0	36	34	36	39	45	61
100	96	10	100.0	1	114	129	146	188	308
100	105	5	0.0	4	10	11	9	18	30
101	73	10	100.0	6	8	10	11	14	22
101	75	10	100.0	74	103	117	133	167	262
101	76	10	100.0	21	28	32	37	47	74
101	84	10	100.0	6	9	10	12	15	23
101	104	10	100.0	6	9	10	12	15	23
102	84	1	100.0	89	86	92	97	113	152
102	85	1	100.0	14	13	14	15	17	24
102	88	15	100.0	6	10	13	15	20	35
102	100	6	0.0	6	14	17	20	26	44
102	102	6	0.0	36	87	102	120	155	258
103	84	2	0.0	108	179	206	238	301	478
103	88	15	100.0	152	249	300	362	477	824
104	9	2	0.0	1	28	32	35	44	66
104	18	6	0.0	1	47	54	61	78	125
104	59	12	0.0	1	28	30	32	37	49

(Continued)

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Table 1 (Concluded)

ORIGIN PE	DESTINATION PE	COMMODITY TYPE	DEDICATION FACTOR	1979 KTONS	PROJECTED TONNAGE (KTONS) 1990	2000	2010	2020	2030
104	82	2	0.0	46	76	88	101	128	203
104	83	6	0.0	5	9	11	12	16	27
104	84	1	100.0	76	71	76	81	94	128
104	84	2	0.0	185	304	352	406	511	812
104	84	6	0.0	905	1946	2273	2658	3418	5655
104	84	8	0.0	6	13	16	20	26	46
104	85	2	0.0	16	27	31	36	46	73
104	100	15	100.0	34	48	54	62	78	122
104	101	6	0.0	42	72	82	93	119	196
104	102	2	0.0	5	8	10	11	14	23
104	105	2	0.0	9	16	18	21	27	43
104	105	6	0.0	24	46	54	63	81	134
105	43	9	100.0	1	114	120	126	140	173
105	72	2	0.0	12	21	24	28	35	56
105	72	15	100.0	6	11	13	15	20	34
105	76	9	100.0	78	112	129	149	188	300
105	83	5	0.0	11	32	38	46	59	99
105	84	2	0.0	27	44	51	59	75	119
105	84	5	0.0	20	56	67	81	104	174
105	84	6	0.0	85	236	282	337	436	727
105	84	9	100.0	6	9	10	12	15	24
105	86	6	0.0	631	1746	2086	2492	3219	5369
105	88	9	100.0	11	16	19	21	27	43
105	88	15	100.0	53	88	106	128	168	291
105	103	9	100.0	6	9	10	11	15	23
105	105	2	0.0	69	113	131	151	190	302
105	105	5	0.0	7	19	23	28	36	60

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TABLE 2

COMMODITY CHARACTERISTICS

	COMMODITY CLASS	TRANS. CLASS	AVG VALUE ($/TON)	ANNUAL HOLDING COST FACTOR	DENSITY (#/CU.FT.)
1	FARM PRODUCTS	3	95.62	.12	46.10
2	FOREST PRODUCTS	10	890.00	.12	45.00
3	FISH & MARINE PROD	8	5.57	.12	93.00
4	METALLIC MINERALS	1	68.53	.12	292.90
5	COAL	1	31.53	.12	51.00
6	NONMETALLIC MINERA	8	5.57	.12	93.10
7	FOOD & FOOD PROD	3	135.49	.12	37.50
8	PULP,PAPER & PROD	10	436.98	.12	47.00
9	CHEMICALS & PROD	4	174.78	.12	70.30
10	PETROLEUM PROD	2	168.16	.12	54.50
11	S,C,G,C	8	64.42	.12	94.00
12	PRIMARY METALS	5	490.33	.12	426.00
13	FABRICATED METALS	5	463.51	.12	483.60
14	MISCELLANEOUS	10	53.98	.12	148.00
15	CRUDE PETROLEUM	7	133.21	.12	54.00

TABLE 3

TRANSPORTATION CLASS CHARACTERISTICS

TRANSPORTATION CLASS	HANDLING CLASS	BARGE TYPE	ANNUAL KTONS
1 COAL & METALLIC MIN.	1	2	53618
2 PETRO PROD-SUPER TAN	3	4	19016
3 FARM & FOOD PROD	1	3	9107
4 CHEM PROD-JUMBO TANK	3	5	12319
5 IRON & STEEL & FE	2	2	3669
6 REGULAR BARGE	1	1	0
7 CRUDE PETRO-JUMBO TN	3	6	4807
8 S,C,G,C-NONMETAL MIN	1	2	18330
9 NOT USED	1	2	0
10 FOREST & PAPER PROD	1	2	5592

TABLE 4

TOWBOAT CHARACTERISTICS

	TOWBOAT CLASS	HORSE-POWER	MAX TOW SIZE	LENGTH (FT)	BEAM (FT)	DRAFT (FT)	BLOCK COEFF	FUEL CONSUMP. (GAL/HR) OPER.	FUEL CONSUMP. (GAL/HR) MNVR.	LABOR COST ($/HR)	OTHER COST ($/HR)	TOTAL VARIABLE COST ($/HR) OPER.	TOTAL VARIABLE COST ($/HR) MNVR.	ANNUAL FIXED COST ($)	AVAILA-BILITY FACTOR
1	1800 BHP TOWBOAT	1530	6	85	35	7.2	.75	64.0	37.0	41.40	20.50	125.90	98.90	352000	.95
2	1800 BHP TOWBOAT	1530	8	85	35	7.2	.75	64.0	37.0	41.40	20.50	125.90	98.90	352000	.95
3	3100 SHP TOWBOAT	2950	13	141	35	7.8	.75	123.0	72.0	44.80	28.50	196.30	145.30	664000	.95
4	4200 SHP TOWBOAT	4000	15	151	40	7.9	.75	167.0	97.0	44.80	35.20	247.00	177.00	822000	.95
5	6550 SHP TOWBOAT	6200	26	185	53	8.8	.75	258.0	151.0	53.80	44.30	356.10	249.10	1056000	.95

TABLE 5

BARGE CHARACTERISTICS

	BARGE CLASS	CAPACITY (TONS)	LENGTH (FT)	BEAM (FT)	DRAFT (FT) EMPTY	DRAFT (FT) LOADED	CLEAR. (FT)	BLOCK COEFF	VAR. COST ($/HR)	FIXED COST ($/YEAR)	AVAIL. FACTOR	SUBSTITUTABLE BARGE CLASSES
1	OPEN HOPPER REGULAR	1070	175	26	1.5	9.5	1.0	.94	1.01	42000	.95	2 3
2	OPEN HOPPER JUMBO	1620	195	35	1.5	9.5	1.0	.94	1.17	52400	.95	1 3
3	COVERED HOPPER	1620	195	35	1.5	9.5	1.0	.94	1.26	59500	.95	
4	PETRO TANK-SUPER	3260	275	50	1.5	9.5	1.0	.94	5.26	179000	.95	6
5	CHEMICAL TANK	1620	195	35	1.5	9.5	1.0	.94	2.88	85900	.95	
6	PETRO TANK-JUMBO	1620	195	35	1.5	9.5	1.0	.94	2.88	85900	.95	4

NOTE: NOMINAL BARGE IS CLASS 2

Table 6

Port Characteristics

	PORT	PL PT.	EETING (MIN/BRG		LOADING (MIN/TON) HC1	HC2	HC3	UNLOADING (MIN/TON) HC1	HC2	HC3	PORT DELAY (HR) HC1	HC2	HC3	AVG WAIT FOR TOW (HR/BRG) TC1	TC2	TC3	TC4	TC5
1	APE UPPER MON RIVER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
2	740 MON R POOL 7		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
3	735 MAXWELL POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
4	730 MON R POOL 4		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
5	725 MON R POOL 3		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
6	715 CLAIRTON/ELIZAB	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
7	APE PITTSBURGH-MON		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
8	APE ALLEGHENY RIVER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
9	286 PITTSBURGH-OHIO		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
10	282 DASHIELDS POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
11	APE MONTGOMERY POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
12	274 NEW CUMBERLAND		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
13	272 PIKE ISLAND		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
14	APE HANNIBAL POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
15	APE WILLOW IS POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
16	APE BELLEVILLE POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
17	APE RACINE POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
18	815 LONDON POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
19	810 MARMET POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
20	805 WINFIELD POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
21	800 LOWER KANAWHA	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
22	250 GALLIPOLIS POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80 4.50	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80
23	APE GREENUP POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.50 4.80	4.80 4.80	4.80 4.80	4.80 4.80	4.80 4.80

(Continued)

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Table 6 (Continued)

	PORT	FLT PT.	FLEETING MIN+MIN/BRG		LOADING (MIN/TON) HC1	HC2	HC3	UNLOADING (MIN/TON) HC1	HC2	HC3	PORT DELAY (HR) HC1	HC2	HC3	AVG WAIT FOR TOW (HR/BRG) TC1	TC2	TC3	TC4	TC5
24	245 BIG SANDY RIVER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80	4.80	4.80	4.80	4.80
														4.80	4.80	4.80	4.80	4.80
25	242 MELDAHL POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.80	4.80	4.80	4.80	4.80
														4.80	4.80	4.80	4.80	4.80
26	APE CINCINNATI AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	5.90	5.90	5.90	5.90	5.90
														5.90	5.90	5.90	5.90	5.90
27	APE KENTUCKY RIVER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
28	APE MCALPINE POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
29	232 LOUISVLLE UPPER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
30	230 LOUISVLLE LOWER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
31	220 CANNELTON POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
32	APE NEWBURGH POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
33	APE GREEN POOLS 2-3		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
34	1005 GREEN POOL 1		20	5	.13	1.50	.27	.22	.93	.39	6.	0.	0.	7.60	7.60	7.60	7.50	7.60
														7.60	7.60	7.60	7.60	7.60
35	220 EVANSVILLE		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
36	APE MT. VERNON		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
37	210 L&D 50 POOL		20	5	.13	1.50	.27	.22	.93	.39	3.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
38	SMITHLAND/51 POOLS		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
39	APE UPP CUMBERLAND		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40
40	1205 BARKLEY POOL		20	5	.13	1.50	.27	.22	.92	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40
41	APE UPP TENN-CLINCH		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40
42	1355 CHICKMAUGA POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40
43	APE CHATTANOOGA TN	•	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40
44	APE GUNTERSVILLE PL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40
45	1320 WHEELER POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
46	1315 WILSON POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40	4.40	4.40	4.40	4.40
														4.40	4.40	4.40	4.40	4.40

(Continued)

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Table 6 (Continued)

	PORT	FLT PT.	FLEETING MIN+MIN/BRG		LOADING (MIN/TON) HC1	HC2	HC3	UNLOADING (MIN/TON) HC1	HC2	HC3	PORT DELAY (HR) HC1	HC2	HC3	AVG WAIT FOR TOW (HR/BRG) TC1	TC2	TC3	TC4	TC5
47	1310 PICKWICK POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
48	APE TENN R/TTW FLTG	•	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
49	1305 KENTUCKY LAKE 2		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
50	1303 KENTUCKY LAKE 1		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
51	APE LOWER TENN-CUMB		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
52	204 L&D 52 POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10
53	202 L&D 53 POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10
54	APE MINN-ST. PAUL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
55	APE MISS POOLS 4-5A		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
56	APE LA CROSSE AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
57	APE DAVNPRT-RK ISLD		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
58	APE POOLS 20-25		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
59	APE CHICAGO AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00
60	APE JOLIET AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00
61	APE LOWR ILLINOIS R		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00
62	APE MISS R POOL 26	•	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00
63	APE OMAHA AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
64	APE KANSAS CITY		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40	4.40 4.40
65	302 ST. LOUIS		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00
66	APE MISS R(OHIO-27)		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00	6.00 6.00
67	200 OHIO R BELOW 53	•	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10
68	APE MEMPHIS AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10	3.10 3.10
69	APE TULSA AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	12.00 12.00	12.00 12.00	12.00 12.00	12.00 12.00	12.00 12.00

(Continued)

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Table 6 (Continued)

	PORT	FLT PT.	FLEETING MIN+	MIN/BRG	LOADING (MIN/TON) MC1	MC2	MC3	UNLOADING (MIN/TON) MC1	MC2	MC3	PORT DELAY (HR) MC1	MC2	MC3	AVG WAIT FOR TOW (HR/BRG) TC1	TC2	TC3	TC4	TC5
70	APE LITTLE ROCK		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	12.00	12.00	12.00	12.00	12.00
														12.00	12.00	12.00	12.00	12.00
71	APE MISS-ARK R JCT		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10	3.10	3.10	3.10	3.10
														3.10	3.10	3.10	3.10	3.10
72	APE VICKSBURG AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10	3.10	3.10	3.10	3.10
														3.10	3.10	3.10	3.10	3.10
73	APE BATON ROUGE		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10	3.10	3.10	3.10	3.10
														3.10	3.10	3.10	3.10	3.10
74	APE CORPUS CHRISTI		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
75	APE HOUSTON AREA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
76	APE PORT ARTHUR		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
77	APE MORGAN CITY		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
78	CORP CHRIS VIA TTW		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
79	HOUSTON VIA TWW		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
80	PORT ARTHUR VIA TWW		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
81	MORGAN CITY VIA TWW		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
82	APE E TERMINUS GIWW		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
83	2610 PENSACOLA FLA		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
84	APE MOBILE AREA	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
85	APE MIDDLE GIWW		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
86	IHNC NEW ORLEANS		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
87	JCT AT IHNC LK	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
88	APE NEW ORLEANS	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10	3.10	3.10	3.10	3.10
														3.10	3.10	3.10	3.10	3.10
89	E TERM GIWW VIA MISS		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
90	PENSACOLA VIA MISS		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
91	MOBILE VIA MISS R		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
92	MID GIWW VIA MISS R		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00

(Continued)

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Table 6 (Concluded)

	PORT	FLT PT.	FLEETING MIN+MIN/BRG		LOADING (MIN/TON) HC1	HC2	HC3	UNLOADING (MIN/TON) HC1	HC2	HC3	PORT DELAY (HR) HC1	HC2	HC3	AVG WAIT FOR TOW (HR/BRG) TC1	TC2	TC3	TC4	TC5
93	IHNC VIA MISS R		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
94	ABERDEEN TTW CUT		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
95	COLUMBUS POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
96	ALICEVILLE POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
97	GAINSVILLE POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
98	BANKHEAD POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
99	HOLT POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
100	OLIV R POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
101	WARRIOR POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
102	DEMOPOLIS POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
103	COFFEVILLE POOL		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
104	APE ALABAMA-COOSA R		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
105	MOBILE RIVER		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
106	ARKANSAS R FLEETING	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	12.00	12.00	12.00	12.00	12.00
														12.00	12.00	12.00	12.00	12.00
107	GREEN RIVER FLEETNG	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	7.60	7.60	7.60	7.60	7.60
														7.60	7.60	7.60	7.60	7.60
108	TENN/OHIO D/S FLEET		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	3.10	3.10	3.10	3.10	3.10
														3.10	3.10	3.10	3.10	3.10
109	TTW/TENN D/S FLEET	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
110	ALABAMA R FLEETING		20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00
111	TTW/BLCK WARR FLEET	*	20	5	.13	1.50	.27	.22	.93	.39	0.	0.	0.	6.00	6.00	6.00	6.00	6.00
														6.00	6.00	6.00	6.00	6.00

(Sheet 5 of 5)

TABLE 7

LOCK CHARACTERISTICS

	LOCK	MAIN CHAMBER CLASS		MAIN CHAMBER AVAIL	MAIN CHAMBER SHARE	AUXILLARY CHAMBER CLASS	AUXILLARY CHAMBER AVAIL	AUXILLARY CHAMBER SHARE	LOCKAGE FEE ($)	KTONS/YEAR UPSTR.	KTONS/YEAR DNSTR.	BARGES /YEAR	AVG DELAY (HOURS)
1	LOCK & DAM 53 (OHIO)	1	1200 X 110	.95	1.00					29355	31062	77331	.33
2	LOCK & DAM 52 (OHIO)	2	1200 X 110	.95	1.00					34788	35960	85108	2.60
3	SMITHLAND L&D	3	1200 X 110	.95	1.00					25892	42500	89733	.69
4	IHNC LOCK	4	640 X 75	.95	1.00					9339	11717	29650	4.61
5	CHEATHAM L&D	5	600 X 110	.95	1.00					2892	187	3935	.11
6	KENTUCKY-BARKLEY LKS	6	800 X 110	.95	1.00					26041	5010	43395	2.84
7	PICKWICK L&D	7	600 X 110	.95	1.00					13325	1424	21232	1.11
8	WATTS BAR L&D	8	360 X 60	.95	1.00					289	124	642	.19
9	CHICKAMAUGA L&D	9	360 X 60	.95	1.00					1072	78	1912	.72
10	NICKAJACK L&D	10	600 X 110	.95	1.00					2723	481	4687	.16
11	GUNTERSVILLE L&D	11	600 X 110	.95	1.00					3416	439	5538	.13
12	WHEELER L&D	12	600 X 110	.95	1.00					5892	1133	9370	.27
13	WILSON L&D	13	600 X 110	.95	1.00					6073	1268	9600	.49
14	BAY SPRINGS LOCK	14	600 X 110	.95	1.00					57	39	127	.00
15	LOCK E (TENN-TOM)	15	600 X 110	.95	1.00					57	39	127	.00
16	LOCK D (TENN-TOM)	15	600 X 110	.95	1.00					57	39	127	.00
17	LOCK C (TENN-TOM)	15	600 X 110	.95	1.00					57	39	127	.00
18	LOCK B (TENN-TOM)	15	600 X 110	.95	1.00					57	39	127	.00
19	LOCK A (TENN-TOM)	15	600 X 110	.95	1.00					57	39	127	.00
20	ABERDEEN L&D	15	600 X 110	.95	1.00					57	39	127	.00
21	COLUMBUS L&D	15	600 X 110	.95	1.00					63	39	134	.00
22	ALICEVILLE L&D	15	600 X 110	.95	1.00					65	42	139	.00
23	GAINESVILLE L&D	16	600 X 110	.95	1.00					65	42	139	.00
24	BANKHEAD L&D	19	600 X 110	.95	1.00					3994	5595	8764	.12
25	HOLT L&D	20	600 X 110	.95	1.00					4000	7990	12339	.21
26	OLIVER L&D	21	460 X 95	.95	1.00					4174	8056	12667	.81
27	WARRIOR L&D	22	600 X 110	.95	1.00					4220	8178	12841	.18
28	DEMOPOLIS L&D	17	600 X 110	.95	1.00					4281	7502	11925	.14
29	COFFEEVILLE L&D	18	600 X 110	.95	1.00					4346	7769	12430	.15

TABLE 8

LOCK CHAMBER CHARACTERISTICS

CLASS	LENGTH (FT)	WIDTH (FT)	CAPACITY (BRGS/YR)	DELAY AT 50% CAPACITY(MIN)	AVG. LOCKAGE TIME (MIN) SINGLE	SETOVER	DOUBLE	LOCKAGE TYPE PARAMETERS R1	R2	R3	PS	PL
1	1200	110	423703	84	15	0	0	20.00	1.00	1.00	0.	0.
2	1200	110	305870	377	34	0	0	20.00	1.00	1.00	0.	0.
3	1200	110	223118	56	43	0	0	20.00	1.00	1.00	0.	0.
4	640	75	36521	47	31	0	0	20.00	1.00	1.00	0.	0.
5	600	110	54282	77	50	0	0	20.00	1.00	1.00	0.	0.
6	800	110	87776	157	100	0	0	20.00	1.00	1.00	0.	0.
7	600	110	48395	77	105	0	0	20.00	1.00	1.00	0.	0.
8	360	60	7443	116	285	0	0	20.00	1.00	1.00	0.	0.
9	360	60	7443	116	285	0	0	20.00	1.00	1.00	0.	0.
10	600	110	43941	77	59	0	0	20.00	1.00	1.00	0.	0.
11	600	110	62468	77	75	0	0	20.00	1.00	1.00	0.	0.
12	600	110	57248	77	132	0	0	20.00	1.00	1.00	0.	0.
13	600	110	42556	95	172	0	0	20.00	1.00	1.00	0.	0.
14	600	110	67568	40	40	0	0	20.00	1.00	1.00	0.	0.
15	600	110	67568	37	37	0	0	20.00	1.00	1.00	0.	0.
16	600	110	67568	36	35	0	0	20.00	1.00	1.00	0.	0.
17	600	110	60248	33	39	0	0	20.00	1.00	1.00	0.	0.
18	600	110	58671	32	39	0	0	20.00	1.00	1.00	0.	0.
19	600	110	39527	24	49	0	0	20.00	1.00	1.00	0.	0.
20	600	110	54166	40	41	0	0	20.00	1.00	1.00	0.	0.
21	460	95	28716	56	80	0	0	20.00	1.00	1.00	0.	0.
22	600	110	61149	37	41	0	0	20.00	1.00	1.00	0.	0.
23	600	110	1	0	1	0	0	20.00	1.00	1.00	0.	0.
24	600	110	1	0	1	0	0	20.00	1.00	1.00	0.	0.
25	1200	110	1	0	1	0	0	20.00	1.00	1.00	0.	0.
26	600	110	1	0	1	0	0	20.00	1.00	1.00	0.	0.
27	600	110	103140	116	101	0	0	20.00	1.00	1.00	0.	0.
28	600	110	1	0	1	0	0	20.00	1.00	1.00	0.	0.
29	360	60	1	0	1	0	0	20.00	1.00	1.00	0.	0.
30	400	60	1	0	1	0	0	20.00	1.00	1.00	0.	0.
31	292	42	1	0	1	0	0	20.00	1.00	1.00	0.	0.

Table 9

Locks

LOCK	CHAMBER SIZE	OPER. POLICY	MULTI-TOW OPTION	READY-TO-SERVE OPTION	SIMPLE TIME CALC.	DETAILED STATS.	SETOVER PROB.	AVG DELAY (HR)	CHMBR SELECT BIAS	RECRE-ATIONAL TRAFFIC	OPEN PASS
SECTOR 9 OHIO RIVER											
1 SMITHLAND L&D								0.	0	NO	NO
CHAMBER 1	1200 X 110	F	NO	NO	YES	NO	0.				
CHAMBER 2	1200 X 110	F	NO	NO	YES	NO	0.				
SECTOR 15 LOWER OHIO RIVER											
1 LOCK & DAM 52 (OHIO)								0.	0	NO	NO
CHAMBER 1	1200 X 110	F	NO	NO	YES	NO	0.				
CHAMBER 2	600 X 110	F	NO	NO	YES	NO	0.				
2 LOCK & DAM 53 (OHIO)								0.	0	NO	NO
CHAMBER 1	1200 X 110	F	NO	NO	YES	NO	0.				
CHAMBER 2	600 X 110	F	NO	NO	YES	NO	0.				
SECTOR 13 LOWER TENNESSSE R											
1 PICKWICK L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
SECTOR 14 LOWER TENN-CUMBERLND											
1 KENTUCKY-BARKLEY LKS								0.	99	NO	NO
CHAMBER 1	600 X 110	F	NO	NO	NO	YES	11.500				
CHAMBER 2	600 X 110	F	NO	NO	NO	YES	2.500				
SECTOR 11 UPPER TENNESSEE R											
1 WATTS BAR L&D	360 X 60	F	NO	NO	YES	NO	0.	0.	0	NO	NO
2 CHICKAMAUGA L&D	360 X 60	F	NO	NO	YES	YES	0.	0.	0	NO	NO
SECTOR 12 MIDDLE TENNESSEE R											
1 NICKAJACK L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
2 GUNTERSVILLE L&D								0.	0	NO	NO
CHAMBER 1	600 X 110	F	NO	NO	YES	NO	0.				
CHAMBER 2	360 X 60	F	NO	NO	YES	NO	0.				
3 WHEELER L&D								0.	0	NO	NO
CHAMBER 1	600 X 110	F	NO	NO	YES	NO	0.				
CHAMBER 2	400 X 60	F	NO	NO	YES	NO	0.				

(Continued)

Table 9 (Concluded)

LOCK	CHAMBER SIZE	OPER. POLICY	MULTI-TOW OPTION	READY-TO-SERVE OPTION	SIMPLE TIME CALC.	DETAILED STATS.	SETOVER PROB.	AVG DELAY (HR)	CHMBR SELECT BIAS	RECRE-ATIONAL TRAFFIC	OPEN PASS
4 WILSON L&D								0.	0	NO	NO
CHAMBER 1	600 X 110	F	NO	NO	YES	NO	0.				
CHAMBER 2	[illegible]92 X 42	F	NO	NO	YES	NO	0.				
SECTOR 10 CUMBERLAND RIVER											
1 CHEATHAM L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
SECTOR 32 INNER HARBOR NAV CAN											
1 IHNC LOCK	640 X 75	F	YES	NO	NO	YES	3.300	0.	0	YES	NO
SECTOR 28 LOWR TOMBIGBEE											
1 DEMOPOLIS L&D	600 X 110	N 1	NO	NO	NO	YES	.300	0.	0	NO	NO
2 COFFEEVILLE L&D	600 X 110	N 1	NO	NO	NO	YES	.200	0.	0	NO	NO
SECTOR 27 BLACK WARRIOR RIVER											
1 BANK AD L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
2 HOLT L D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
3 OLIVER L&D	500 X 95	F	NO	NO	NO	YES	5.200	0.	0	NO	NO
4 WARRIOR L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
SECTOR 26 TENNESSEE-TOMBIGBEE											
1 BAY SPRINGS LOCK	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
2 LOCK E (TENN-TOM)	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
3 LOCK D (TENN-TOM)	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
4 LOCK C (TENN-TOM)	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
5 LOCK B (TENN-TOM)	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
6 LOCK A (TENN-TOM)	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
7 ABERDEEN L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
8 COLUMBUS L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
9 ALICEVILLE L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO
10 GAINESVILLE L&D	600 X 110	F	NO	NO	YES	NO	0.	0.	0	NO	NO

Table 10

Lockage Times I: Approach and Entry Distributions

	APPROACH (OR SIMPLIFIED LOCKAGE DISTRIBUTIONS) FLY OR EXCHANGE UP (*:SINGLE)	DOWN (*:SETOVER)	TURNBACK UP (*:MULTICUT)	DOWN (*:TURNBACK)	ENTRY LOADED TOW	EMPTY TOW
SECTOR 9						
LOCK 1						
CHAMBER 1	K 43.40*	K 0. *	K 0. *	K 0. *		
CHAMBER 2	K 43.40*	K 0. *	K 0. *	K 0. *		
SECTOR 15						
LOCK 1						
CHAMBER 1	K 34.30*	K 0. *	K 0. *	K 0. *		
CHAMBER 2	K 34.30*	K 0. *	K 0. *	K 0. *		
LOCK 2						
CHAMBER 1	K 14.80*	K 0. *	K 0. *	K 0. *		
CHAMBER 2	K 14.80*	K 0. *	K 0. *	K 0. *		
SECTOR 13						
LOCK 1	K 39.50*	K 71.70*	K 96.90*	K 16.90*		
SECTOR 14						
LOCK 1						
CHAMBER 1	K 11.40	K 9.90	K 3.60	K 2.90	K 8.00	K 8.00
CHAMBER 2	K 19.20	K 16.70	K 2.70	K 2.00	K 9.60	K 9.60
SECTOR 11						
LOCK 1	K 36.30*	K 77.00*	K 72.10*	K 18.60*		
LOCK 2	K 28.80*	K 0. *	K 63.90*	K 6.50*		
SECTOR 12						
LOCK 1	K 41.40*	K 58.10*	K 94.70*	K 15.40*		
LOCK 2						
CHAMBER 1	K 36.70*	K 56.60*	K100.20*	K 14.70*		
CHAMBER 2	K 30.30*	K 45.00*	K 80.10*	K 13.40*		
LOCK 3						
CHAMBER 1	K 48.70*	K 59.80*	K 92.70*	K 14.20*		
CHAMBER 2	K 32.50*	K 43.60*	K 59.50*	K 13.00*		

(Continued)

(Sheet 1 of 7)

Table 10 (Continued)

	APPROACH (OR SIMPLIFIED LOCKAGE DISTRIBUTIONS)				ENTRY	
	FLY OR EXCHANGE		TURNBACK			
	UP (*:SINGLE)	DOWN (*:SETOVER)	UP (*:MULTICUT)	DOWN (*:TURNBACK)	LOADED TOW	EMPTY TOW
LOCK 4						
CHAMBER 1	K 53.00*	K 66.10*	K112.60*	K 23.50*		
CHAMBER 2	K 62.20*	K 0. *	K 91.10*	K 10.10*		
SECTOR 10						
LOCK 1	K 41.40*	K 65.70*	K 99.40*	K 16.60*		
SECTOR 32						
LOCK 1	K 10.40	K 9.90	K 5.80	K 6.00	K 8.00	K 8.00
SECTOR 28						
LOCK 1	K 10.70	K 11.00	K 6.00	K 8.30	K 5.00	K 5.00
LOCK 2	K 9.30	K 10.40	K 4.20	K 5.20	K 4.80	K 4.80
SECTOR 27						
LOCK 1	K 39.90*	K 64.30*	K116.00*	K 15.50*		
LOCK 2	K 46.90*	K 74.00*	K 72.40*	K 13.40*	K 6.90	K 6.90
LOCK 3	K 8.00	K 12.40	K 4.40	K 4.20		
LOCK 4	K 40.20*	K 56.20*	K 83.40*	K 15.10*		
SECTOR 26						
LOCK 1	K 35.50*	K 47.50*	K 0. *	K 6.50*		
LOCK 2	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 3	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 4	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 5	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 6	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 7	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 8	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 9	K 37.00*	K 49.00*	K 0. *	K 8.00*		
LOCK 10	K 40.00*	K 52.00*	K 0. *	K 11.00*		

(Continued)

(Sheet 2 of 7)

Table 10 (Continued)

	CHAMBERING		EXIT			
			FLY OR EXCHANGE		TURNBACK	
	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM
SECTOR 9						
LOCK 1						
CHAMBER 1						
CHAMBER 2						
SECTOR 15						
LOCK 1						
CHAMBER 1						
CHAMBER 2						
LOCK 2						
CHAMBER 1						
CHAMBER 2						
SECTOR 13						
LOCK 1						
SECTOR 14						
LOCK 1						
CHAMBER 1	K 18.00	K 18.00	K 7.70	K 9.00	K 7.60	K 5.80
CHAMBER 2	K 17.90	K 17.50	K 8.70	K 7.90	K 9.30	K 6.50
SECTOR 11						
LOCK 1						
LOCK 2						
SECTOR 12						
LOCK 1						
LOCK 2						
CHAMBER 1						
CHAMBER 2						
LOCK 3						
CHAMBER 1						
CHAMBER 2						

(Continued)

(Sheet 3 of 7)

Table 10 (Continued)

	CHAMBERING		EXIT			
			FLY OR EXCHANGE		TURNBACK	
	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM	UPSTREAM	DOWNSTREAM
LOCK 4						
CHAMBER 1						
CHAMBER 2						
SECTOR 10						
LOCK 1						
SECTOR 32						
LOCK 1	K 7.00	K 7.00	K 8.20	K 5.20	K 8.50	K 5.90
SECTOR 28						
LOCK 1	K 11.00	K 11.00	K 9.40	K 10.10	K 5.60	K 6.00
LOCK 2	K 10.50	K 10.90	K 8.20	K 9.20	K 6.90	K 6.50
SECTOR 27						
LOCK 1						
LOCK 2						
LOCK 3	K 13.90	K 14.10	K 8.10	K 9.00	K 5.50	K 6.30
LOCK 4						
SECTOR 26						
LOCK 1						
LOCK 2						
LOCK 3						
LOCK 4						
LOCK 5						
LOCK 6						
LOCK 7						
LOCK 8						
LOCK 9						
LOCK 10						

(Continued)

(Sheet 4 of 7)

Table 10 (Continued)

	EXTRA TIME FOR SETOVER	MULTICUT, EXTRA TIME PER CUT	LIGHT BOAT ENTRY/EXIT
SECTOR 9			
LOCK 1			
CHAMBER 1			
CHAMBER 2			
SECTOR 15			
LOCK 1			
CHAMBER 1			
CHAMBER 2			
LOCK 2			
CHAMBER 1			
CHAMBER 2			
SECTOR 13			
LOCK 1			
SECTOR 14			
LOCK 1			
CHAMBER 1	K 26.50	K 99.70	K 11.10
CHAMBER 2	K 20.50	K103.90	K 16.40
SECTOR 11			
LOCK 1			
LOCK 2			
SECTOR 12			
LOCK 1			
LOCK 2			
CHAMBER 1			
CHAMBER 2			
LOCK 3			
CHAMBER 1			
CHAMBER 2			

(Continued)

(Sheet 5 of 7)

Table 10 (Continued)

	EXTRA TIME FOR SETOVER	MULTICUT, EXTRA TIME PER CUT	LIGHT BOAT ENTRY/EXIT
LOCK 4			
CHAMBER 1			
CHAMBER 2			
SECTOR 10			
LOCK 1			
SECTOR 32			
LOCK 1	K 13.70	K 41.10	K 8.60
SECTOR 28			
LOCK 1	K 11.80	K 0.	K 20.60
LOCK 2	K 16.40	K 0.	K 9.84
SECTOR 27			
LOCK 1			
LOCK 2			
LOCK 3	K 10.00	K 61.30	K 11.60
LOCK 4			
SECTOR 26			
LOCK 1			
LOCK 2			
LOCK 3			
LOCK 4			
LOCK 5			
LOCK 6			
LOCK 7			
LOCK 8			
LOCK 9			
LOCK 10			

(Continued)

(Sheet 6 of 7)

Table 10 (Concluded)

	Vessels per Day				Maximum Wait	Entry/Exit Time	
	Weekday Up	Weekday Down	Weekend Up	Weekend Down	(Lockages)	First Vessel	Following Vessels
SECTOR 32							
LOCK 1	4	5	4	5	3	K 0.60	K 1.00

(Sheet 7 of 7)

TABLE 11

RIVER SEGMENT DATA

RIVER SEGMENT	LENGTH (MI)	NUMBER LOCKS	------ O&M EXPENDITURES ($1000) ------ LOCKS	OTHER COE	COAST GD	TOTAL	IMPLEMENTATION EXPENDITURES	TOTAL GOVT. EXPENDITURES	SEGMENT FEE (MILLS/TON-MI)
1 OHIO RIVER	980.0	3	1.0	0.	0.	1.0	0.	1.0	
2 ALABAMA RIVER	230.0	0	1.0	0.	0.	1.0	0.	1.0	
3 MONONGAHELA RIVER	103.5	0	1.0	0.	0.	1.0	0.	1.0	
4 KANAWHA RIVER	86.0	0	1.0	0.	0.	1.0	0.	1.0	
5 KENTUCKY RIVER	67.3	0	1.0	0.	0.	1.0	0.	1.0	
6 TENNESSEE RIVER, LOW	220.0	2	1.0	0.	0.	1.0	0.	1.0	
7 TENNESSEE RIVER, UP	387.6	6	1.0	0.	0.	1.0	0.	1.0	
8 CUMBERLAND RIVER	166.1	1	1.0	0.	0.	1.0	0.	1.0	
9 UPPER MISSISSIPPI	842.2	0	1.0	0.	0.	1.0	0.	1.0	
10 LOWER MISSISSIPPI	852.0	0	1.0	0.	0.	1.0	0.	1.0	
11 MISSOURI RIVER	696.0	0	1.0	0.	0.	1.0	0.	1.0	
12 ILLINOIS WATERWAY	317.0	0	1.0	0.	0.	1.0	0.	1.0	
13 ARKANSAS RIVER	375.0	0	1.0	0.	0.	1.0	0.	1.0	
14 GIWW WEST	1216.0	0	1.0	0.	0.	1.0	0.	1.0	
15 MID GIWW-MOBILE HBR	133.8	1	1.0	0.	0.	1.0	0.	1.0	
16 GIWW EAST	558.4	0	1.0	0.	0.	1.0	0.	1.0	
17 MOBILE & TOMBIGBEE R	243.5	2	1.0	0.	0.	1.0	0.	1.0	
18 BLACK WARRIOR RIVER	173.2	4	1.0	0.	0.	1.0	0.	1.0	
19 TENN-TOM WATERWAY	232.2	10	1.0	0.	0.	1.0	0.	1.0	
20 GREEN-BARREN RIVERS	87.3	0	1.0	0.	0.	1.0	0.	1.0	
TOTAL	7973.9	29	20.0	0.	0.	20.0	0.	20.0	

Table 12

Waterway Network - River Points, Reaches, and Bends

RIVER POINTS	REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
RIVER SYSTEM 1 OHIO RIVER (1)												
SECTOR 3 OHIO RIVER												
0. PORT 1 286 PITTSBURGH-OHIO	R- 1	7.0	10.0	10.0	.7	.66	.66					
7.0 PORT 2 282 DASHIELDS POOL	R- 2	14.0	14.6	12.0	.7	.66	.66					
21.0 PORT 3 APE MONTGOMERY POOL	R- 3	22.1	22.0	12.0	.8	.66	.66					
43.1 PORT 4 274 NEW CUMBERLAND	R- 4	26.3	18.0	12.0	.8	.66	.66					
69.4 PORT 5 272 PIKE ISLAND	R- 5	35.6	18.0	12.0	.9	.66	.66					
105.0 PORT 6 APE HANNIBAL POOL	R- 6	39.4	21.0	11.0	.9	.66	.66					
144.4 PORT 7 APE WILLOW IS POOL	R- 7	37.4	24.1	11.0	1.0	.66	.66					
181.8 PORT 8 APE BELLEVILLE POOL	R- 8	39.7	36.8	11.0	1.1	.66	.66					
221.5 PORT 9 APE RACINE POOL	R- 9	44.9	44.8	19.5	1.2	.66	.66					
266.4 PORT 10 250 GALLIPOLIS POOL												
SECTOR 5 OHIO RIVER												
0. PORT 1 250 GALLIPOLIS POOL	R- 1	44.4	41.4	21.0	1.4	.78	.78					
44.4 PORT 2 APE GREENUP POOL	R- 2	7.1	41.4	21.6	1.4	.78	.78					
51.5 PORT 3 245 BIG SANDY RIVER	R- 3	87.4	19.5	9.9	1.7	.78	.78					
138.9 PORT 4 242 MELDAHL POOL	R- 4	66.5	19.6	12.6	1.9	.78	.78					
205.4 PORT 5 APE CINCINNATI AREA	R- 5	74.8	16.0	12.6	1.9	.78	.74					
280.2 PORT 6 APE MCALPINE POOL												
SECTOR 7 OHIO RIVER												
0. PORT 1 APE MCALPINE POOL	R- 1	58.2	24.0	19.0	1.9	.76	.76					
58.2 PORT 2 232 LOUISVLLE UPPER	R- 2	5.0	13.0	10.6	2.0	.76	.76					
63.2 PORT 3 230 LOUISVLLE LOWER	R- 3	59.0	21.0	12.6	1.5	.76	.76					
122.2 PORT 4 228 CANNELTON POOL	R- 4	90.7	25.0	12.6	1.0	.76	.76					
212.9 PORT 5 APE NEWBURGH POOL	R- 5	25.7	15.0	10.1	.7	.76	.76					
238.6 PORT 6 GREEN RIVER FLEETNG												
SECTOR 9 OHIO RIVER												
0. PORT 1 220 EVANSVILLE	R- 1	43.6	28.0	11.5	1.1	.79	.79					
43.6 PORT 2 APE MT. VERNON	R- 2	30.0	25.0	11.5	1.6	.79	.79					
73.6 PORT 3 210 L&D 50 POOL	R 3	32.0	28.0	11.5	1.5	.79	.79					
105.6 PORT 4 SMITHLAND/51 POOLS	R 4	14.3	40.0	11.5	1.5	.79	.79					
119.9 LOCK 1 SMITHLAND L&D	R- 5	28.7	25.0	11.5	1.4	.79	.79					
148.6 PORT 5 204 L&D 52 POOL												

(Continued)

(Sheet 1 of 10)

Table 12 (Continued)

RIVER POINTS	REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
SECTOR 15 LOWER OHIO RIVER												
0. PORT 1 TENN/OHIO D/S FLEET	R- 1	4.4	17.0	11.0	1.6	.79	.79					
4.4 LOCK 1 LOCK & DAM 52 (OHIO)	R- 2	12.1	17.0	11.0	1.9	.79	.79					
16.5 PORT 2 202 L&D 53 POOL	R- 3	11.6	17.0	11.0	1.5	.79	.79					
28.1 LOCK 2 LOCK & DAM 53 (OHIO)	R- 4	18.9	15.0	11.0	1.5	.79	.79					
47.0 PORT 3 200 OHIO R BELOW 53												
RIVER SYSTEM 2 ALABAMA RIVER (2)												
SECTOR 23 ALABAMA RIVER												
0. PORT 1 APE ALABAMA-COOSA R	R- 1	230.0	10.5	10.5	1.5	.80	.80					
230.0 PORT 2 ALABAMA R FLEETING												
RIVER SYSTEM 3 MONONGAHELA RIVER (3)												
SECTOR 1 MONUNGAHELA UPPER												
0. PORT 1 APE UPPER MON RIVER	R- 1	12.9	11.0	10.0	.4	.68	.68					
12.9 PORT 2 740 MON R POOL 7	R- 2	14.8	11.0	10.0	.5	.68	.68					
27.7 PORT 3 735 MAXWELL POOL	R- 3	21.7	14.0	11.0	.6	.68	.68					
49.4 PORT 4 730 MON R POOL 4	R- 4	18.7	16.0	11.0	.7	.68	.68					
68.1 PORT 5 725 MON R POOL 3	R- 5	15.9	16.0	9.5	.8	.68	.68					
84.0 PORT 6 715 CLARITON/ELIZAB												
SECTOR 2 MONONGAHELA LOWER												
0. PORT 1 715 CLARITON/ELIZAB	R- 1	14.0	14.0	11.0	1.1	.68	.68					
14.0 PORT 2 APE PITTSBURGH-MON	R- 2	5.0	14.0	11.0	1.3	.68	.68					
19.0 PORT 3 APE ALLEGHENY RIVER	R- 3	.5	14.0	11.0	1.3	.68	.68					
19.5 PORT 4 286 PITTSBURGH-OHIO												
RIVER SYSTEM 4 KANAWHA RIVER (4)												
SECTOR 4 KANAWHA RIVER												
0. PORT 1 815 LONDON POOL	R- 1	12.5	24.1	13.0	1.5	.62	.62					
12.5 PORT 2 810 MARMET POOL	R- 2	28.5	20.7	10.5	1.1	.62	.62					
41.0 PORT 3 805 WINFIELD POOL	R- 3	45.0	20.7	9.1	.6	.62	.62					
86.0 PORT 4 800 LOWER KANAWHA												

(Continued)

(Sheet 2 of 10)

Table 12 (Continued)

RIVER POINTS	REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
RIVER SYSTEM 5 KENTUCKY RIVER (5)												
SECTOR 6 KENTUCKY RIVER												
0. PORT 1 APE KENTUCKY RIVER	R- 1	67.3	10.0	6.1	.5	.41	.41					
67.3 PORT 2 APE MCALPINE POOL												
RIVER SYSTEM 6 TENNESSEE RIVER, LOW (6)												
SECTOR 13 LOWER TENNESSEE R												
0. PORT 1 TTW/TENN D/S FLEET	R- 1	8.4	20.7	11.1	.9	.65	.65					
8.4 LOCK 1 PICKWICK L&D	R- 2	107.0	20.7	11.1	.9	.65	.65					
115.4 PORT 2 1305 KENTUCKY LAKE 2	R- 3	77.6	20.7	11.1	.9	.65	.65					
193.0 PORT 3 1303 KENTUCKY LAKE 1												
SECTOR 14 LOWER TENN-CUMBERLND												
0. PORT 1 1303 KENTUCKY LAKE 1	R- 1	2.0	17.0	11.0	3.1	.55	.55					
2.0 LOCK 1 KENTUCKY-BARKLEY LKS	R- 2	12.0	17.0	11.0	3.1	.55	.55					
14.0 PORT 2 APE LOWER TENN-CUMB	R- 3	13.0	17.0	11.0	3.1	.55	.55					
27.0 PORT 3 204 L&D 52 POOL												
RIVER SYSTEM 7 TENNESSEE RIVER, UP (7)												
SECTOR 11 UPPER TENNESSEE R												
0. PORT 1 APE UPP TENN-CLINCH	R- 1	72.5	20.7	9.4	.5	.89	.89					
72.5 LOCK 1 WATTS BAR L&D	R- 2	29.5	20.7	9.4	.5	.89	.89					
102.0 PORT 2 1355 CHICKMAUGA POOL	R- 3	29.4	20.7	9.4	.5	.89	.89					
131.4 LOCK 2 CHICKAMAUGA L&D	R- 4	22.0	20.7	9.4	.5	.89	.89					
153.4 PORT 3 APE CHATTANOOGA TN												
SECTOR 12 MIDDLE TENNESSEE R												
0. PORT 1 APE CHATTANOOGA TN	R- 1	24.6	20.7	11.1	.5	1.20	1.20					
24.6 LOCK 1 NICKAJACK L&D	R- 2	39.6	20.7	11.1	.5	1.20	1.20					
64.2 PORT 2 APE GUNTERSVILLE PL	R- 3	36.1	20.7	11.1	.5	1.20	1.20					
100.3 LOCK 2 GUNTERSVILLE L&D	R- 4	43.0	20.7	11.1	.5	1.20	1.20					
149.3 PORT 3 1320 WHEELER POOL	R- 5	25.1	20.7	11.1	.5	1.20	1.20					
174.4 LOCK 3 WHEELER L&D	R- 6	14.9	20.7	11.1	.5	1.20	1.20					
189.3 PORT 4 1315 WILSON POOL	R- 7	.6	20.7	11.1	.5	1.20	1.20					
183.9 LOCK 4 WILSON L&D	R- 8	3.4	20.7	11.1	.5	1.20	1.20					

(Continued)

(Sheet 3 of 10)

Table 12 (Continued)

RIVER POINTS			REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
193.3	PORT 5	1310 PICKWICK POOL	R- 9	40.9	20.7	11.1	.5	1.20	1.20					
234.2	PORT 6	APE TENN R/TTW FLTG												
RIVER SYSTEM 8 CUMBERLAND RIVER (8)														
SECTOR 10 CUMBERLAND RIVER														
0.	PORT 1	APE UPP CUMBERLAND	R- 1	50.0	22.0	11.0	2.2	.96	.96					
50.0	LOCK 1	CHEATHAM L&D	R- 2	45.7	22.0	11.0	2.2	.96	.96					
95.7	PORT 2	1205 BARKLEY POOL	R- 3	70.4	22.0	11.0	2.2	.96	.96					
166.1	PORT 3	1303 KENTUCKY LAKE 1												
RIVER SYSTEM 9 UPPER MISSISSIPPI (9)														
SECTOR 16 UPPR MISS ABVE ILL R														
0.	PORT 1	APE MINN-ST. PAUL	R- 1	88.5	12.0	10.5	1.0	.44	.44					
88.5	PORT 2	APE MISS POOLS 4-5A	R- 2	76.8	12.0	10.5	1.0	.44	.44					
165.3	PORT 3	APE LA CROSSE AREA	R- 3	189.0	12.0	10.5	1.0	.44	.44					
354.3	PORT 4	APE DAVNPRT-RK ISLD	R- 4	189.0	12.0	10.5	1.0	.44	.44					
543.3	PORT 5	APE POOLS 20-25	R- 5	81.2	12.0	10.5	1.0	.44	.44					
624.5	PORT 6	APE MISS R POOL 26												
SECTOR 18 UP MISS (ILL R-MO R)														
0.	PORT 1	APE MISS R POOL 26	R- 1	22.7	13.0	11.0	.6	.19	.19					
22.7	PORT 2	302 ST. LOUIS												
SECTOR 20 UPPR MISS BELOW MO R														
0.	PORT 1	302 ST. LOUIS	R- 1	49.0	13.0	11.0	1.9	.44	.44					
49.0	PORT 2	APE MISS R(OHIO-27)	R- 2	146.0	13.0	11.0	.7	.44	.44					
195.0	PORT 3	200 OHIO R BELOW 53												
RIVER SYSTEM 10 LOWER MISSISSIPPI (10)														
SECTOR 21 LOWER MISS ABOVE ARK														
0.	PORT 1	200 OHIO R BELOW 53	R- 1	197.0	16.1	11.0	2.0	1.05	1.05					
197.0	PORT 2	APE MEMPHIS AREA	R- 2	175.0	16.1	11.0	2.0	1.05	1.05					
372.0	PORT 3	APE MISS-ARK R JCT												

(Continued)

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Table 12 (Continued)

RIVER POINTS				REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
SECTOR 23 LOWER MISS BELOW ARK															
0.	PORT	1	APE MISS-ARK R JCT	R- 1	225.0	22.0	18.0	1.5	1.05	1.05					
225.0	PORT	2	APE VICKSBURG AREA	R- 2	121.0	22.0	18.0	1.5	1.05	1.05					
346.0	PORT	3	APE BATON ROUGE	R- 3	134.0	46.0	46.0	1.6	1.05	1.05					
480.0	PORT	4	APE NEW ORLEANS												
RIVER SYSTEM 11 MISSOURI RIVER (11)															
SECTOR 19 MISSOURI RIVER															
0.	PORT	1	APE OMAHA AREA	R- 1	342.0	16.8	9.2	2.2	.75	.75					
342.0	PORT	2	APE KANSAS CITY	R- 2	354.0	16.6	9.2	2.2	.75	.75					
696.0	PORT	3	302 ST. LOUIS												
RIVER SYSTEM 12 ILLINOIS WATERWAY (12)															
SECTOR 17 ILLINOIS WATERWAY															
0.	PORT	1	APE CHICAGO AREA	R- 1	54.0	17.4	11.5	1.0	.52	.52					
54.0	PORT	2	APE JOLIET AREA	R- 2	89.0	17.4	11.5	1.0	.52	.52					
143.0	PORT	3	APE LOWR ILLINOIS R	R- 3	174.0	16.7	10.5	.8	.52	.52					
317.0	PORT	4	APE MISS R POOL 26												
RIVER SYSTEM 13 ARKANSAS RIVER (13)															
SECTOR 22 ARKANSAS WATERWAY															
0.	PORT	1	APE TULSA AREA	R- 1	275.0	10.7	10.5	1.9	.50	.50					
275.0	PORT	2	APE LITTLE ROCK	R- 2	100.0	10.7	10.5	1.9	.50	.50					
375.0	PORT	3	ARKANSAS R FLEETING												
RIVER SYSTEM 14 GIWW WEST (14)															
SECTOR 24 GIWW WEST															
0.	PORT	1	APE CORPUS CHRISTI	R- 1	214.0	13.0	13.0	0.	.80	.80					
214.0	PORT	2	APE HOUSTON AREA	R- 2	118.0	13.0	13.0	0.	.80	.80					
332.0	PORT	3	APE PORT ARTHUR	R- 3	173.0	13.0	13.0	0.	.80	.80					
505.0	PORT	4	APE MORGAN CITY	R- 4	103.0	13.0	13.0	0.	.80	.80					
608.0	PORT	5	APE NEW ORLEANS												

(Continued)

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Table 12 (Continued)

River Points				Reach or Bend	Length (MI)	Depth (FT) Avg	Depth (FT) Min	Current (MPH)	Coefficients UP	Coefficients DN	Coefficients FL	Bend Radius (FT)	Bend Width (FT)	Clearance Width (FT)	Flanking Length (FT)
SECTOR 34 WEST GIWW VIA TN-TOM															
0.	PORT	1	CORP CHRIS VIA TTW	R- 1	214.0	13.8	13.8	0.	.80	.80					
214.0	PORT	2	HOUSTON VIA TWW	R- 2	118.0	13.8	13.8	0.	.80	.80					
332.0	PORT	3	PORT ARTHUR VIA TWW	R- 3	173.0	13.8	13.8	0.	.80	.80					
505.0	PORT	4	MORGAN CITY VIA TWW	R- 4	103.0	13.8	13.8	0.	.80	.80					
608.0	PORT	5	IHNC-NEW ORLEANS												
RIVER SYSTEM 15 MID GIWW-MOBILE HBR (15)															
SECTOR 31 MID-GIWW & MOBILE															
0.	PORT	1	APE MOBILE AREA	R- 1	46.6	13.8	13.8	0.	.53	.53					
46.6	PORT	2	APE MIDDLE GIWW	R- 2	87.0	13.8	13.8	0.	.53	.53					
133.6	PORT	3	IHNC-NEW ORLEANS												
SECTOR 32 INNER HARBOR NAV CAN															
0.	PORT	1	JCT AT IHNC LK	R- 1	.1	10.5	10.5	1.5	1.00	1.00					
.1	LOCK	1	IHNC LOCK	R- 2	.1	10.5	10.5	1.5	1.00	1.00					
.2	PORT	2	APE NEW ORLEANS												
RIVER SYSTEM 16 GIWW EAST (16)															
SECTOR 25 GIWW EAST															
0.	PORT	1	APE E TERMINUS GIWW	R- 1	166.0	13.8	13.8	0.	.76	.76					
166.0	PORT	2	2610 PENSACOLA FLA	R- 2	46.4	13.8	13.8	0.	.76	.76					
212.4	PORT	3	APE MOBILE AREA												
SECTOR 33 EAST GIWW VIA MISS R															
0.	PORT	1	E TERM GIWW VIA MISS	R- 1	166.0	13.8	13.8	0.	.76	.76					
166.0	PORT	2	PENSACOLA VIA MISS	R- 2	46.4	13.8	13.8	0.	.76	.76					
212.4	PORT	3	MOBILE VIA MISS R	R- 3	46.6	13.8	13.8	0.	.53	.53					
259.0	PORT	4	MID-GIWW VIA MISS R	R- 4	87.0	13.8	13.8	0.	.53	.53					
346.0	PORT	5	IHNC VIA MISS R												
RIVER SYSTEM 17 MOBILE & TOMBIGBEE R (17)															
SECTOR 28 LOWR TOMBIGBEE															
217.0	PORT	1	DEMOPOLIS POOL	R- 1	3.6	11.4	11.4	1.5	1.51	.99					

(Continued)

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Table 12 (Continued)

	RIVER POINTS	REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
213.4	LOCK 1 DEMOPOLIS L&D	R- 2	7 6	15.7	15.7	1.5	1.51	.33					
205.8	TERM 1 BEND TERMINATOR	B- 1	.5	15.5	15.5	1.5	1.25	.78	.20	4900.0	233.0	80.0	800.0
205.3	TERM 2 BEND TERMINATOR	R- 3	.6	16.0	16.0	1.5	1.51	.99					
204.7	TERM 3 BEND TERMINATOR	B- 2	.5	16.4	16.4	1.5	1.16	71	.20	3000.0	256.0	80.0	800.0
204.2	TERM 4 BEND TERMINATOR	R- 4	.5	13.8	13.8	1.5	1.51	.93					
203.7	TERM 5 BEND TERMINATOR	B- 3	.4	14.8	14.8	1.5	1.18	.73	.20	3500.0	290.0	80.0	800.0
203.3	TERM 6 BEND TERMINATOR	R- 5	.2	13.6	13.6	1.5	1.51	.99					
203.1	PORT 2 COFFEVILLE POOL	R- 6	5.1	13.4	13.4	1.5	1.51	.99					
198.0	TERM 7 BEND TERMINATOR	B- 4	.6	12.9	12.9	1.5	.64	.45	.20	2300.0	200.0	80.0	800.0
197.4	TERM 8 BEND TERMINATOR	R- 7	1.1	11.4	11.4	1.5	1.51	.99					
196.3	TERM 9 BEND TERMINATOR	B- 5	.5	13.5	13.5	1.5	1.18	.73	.20	3500.0	350.0	80.0	800.0
195.8	TERM 10 BEND TERMINATOR	R- 8	2.5	13.5	13.5	1.5	1.51	.99					
193.3	TERM 11 BEND TERMINATOR	B- 6	1.2	14.3	14.3	1.5	1.09	.66	.20	1800.0	240.0	80.0	800.0
192.1	TERM 12 BEND TERMINATOR	R- 9	.6	15.0	15.0	1.5	1.51	.99					
191.5	TERM 13 BEND TERMINATOR	B- 7	.9	15.5	15.5	1.5	1.10	.66	.20	1900.0	288.0	80.0	800.0
190.6	TERM 14 BEND TERMINATOR	R- 10	.8	17.0	17.0	1.5	1.51	.99					
189.8	TERM 15 BEND TERMINATOR	B- 8	.5	19.8	19.8	1.5	1.18	.73	.20	3500.0	362.0	80.0	800.0
189.3	TERM 16 BEND TERMINATOR	B- 9	1.0	19.2	19.2	1.5	.45	.33	.20	1500.0	300.0	80.0	800.0
188.3	TERM 17 BEND TERMINATOR	R- 11	1.1	17.0	17.0	1.5	1.51	.93					
187.2	TERM 18 BEND TERMINATOR	B- 10	.5	15.0	15.0	1.5	1.69	.66	.20	1800.0	400.0	[illegible]	800.0
186.7	TERM 19 BEND TERMINATOR	R- 12	.6	14.0	14.0	1.5	1.51	.99					
186.1	TERM 20 BEND TERMINATOR	B- 11	1.1	12.0	12.0	1.5	1.07	.64	.20	1300.0	350.0	80.0	800.0
185.0	TERM 21 BEND TERMINATOR	R- 13	.4	11.5	11.5	1.5	1.51	.99					
184.6	TERM 22 BEND TERMINATOR	B- 12	.8	11.2	11.2	1.5	.66	.47	.20	2400.0	302.0	80.0	800.0
183.8	TERM 23 BEND TERMINATOR	R- 14	.8	16.0	16.0	1.5	1.51	.93					
183.0	TERM 24 BEND TERMINATOR	B- 13	.6	22.3	22.3	1.5	1.13	.68	.20	2400.0	328.0	80.0	800.0
182.2	TERM 25 BEND TERMINATOR	B- 14	1.0	23.0	23.0	1.5	1.08	.64	.20	1500.0	335.0	80.0	800.0
181.2	TERM 26 BEND TERMINATOR	R- 15	.7	20.5	20.5	1.5	1.51	.99					
180.5	TERM 27 BEND TERMINATOR	B- 15	.8	17.7	17.7	1.5	1.05	.62	.20	1000.0	393.0	80.0	800.0
179.7	TERM 28 BEND TERMINATOR	B- 16	1.8	20.2	20.2	1.5	1.07	.64	.20	1400.0	370.0	80.0	800.0
177.9	TERM 29 BEND TERMINATOR	B- 17	.9	23.8	23.8	1.5	1.05	.62	.20	1000.0	400.0	80.0	800.0
177.0	TERM 30 BEND TERMINATOR	R- 16	.6	18.5	18.5	1.5	1.51	.99					
176.4	TERM 31 BEND TERMINATOR	B- 18	.7	21.3	21.3	1.5	1.18	.73	.20	3500.0	335.0	80.0	800.0
175.7	TERM 32 BEND TERMINATOR	B- 19	.6	22.0	22.0	1.5	1.18	.73	.20	3500.0	350.0	80.0	800.0
175.1	TERM 33 BEND TERMINATOR	B- 20	1.0	23.0	23.0	1.5	1.21	.75	.20	4000.0	350.0	80.0	800.0
174.1	TERM 34 BEND TERMINATOR	B- 21	1.1	24.0	24.0	1.5	1.03	.71	.20	4000.0	150.0	80.0	800.0
173.0	TERM 35 BEND TERMINATOR	R- 17	1.7	25.0	25.0	1.5	1.51	.99					
171.3	TERM 36 BEND TERMINATOR	B- 22	.6	26.0	26.0	1.5	.16	.71	.20	3000.0	350.0	80.0	800.0
170.7	TERM 37 BEND TERMINATOR	R- 18	3.9	27.2	27.2	1.5	1.51	.99					
166.8	TERM 38 BEND TERMINATOR	B- 23	.4	32.0	32.0	1.5	1.08	.64	.20	1500.0	353.0	80.0	800.0
166.4	TERM 39 BEND TERMINATOR	B- 24	.9	28.4	28.4	1.5	1.13	.68	.20	2500.0	374.0	80.0	800.0
165.5	TERM 40 BEND TERMINATOR	R- 19	4.1	27.5	27.5	1.5	1.51	.99					
161.4	TERM 41 BEND TERMINATOR	B- 25	.4	23.4	23.4	1.5	1.09	.66	.20	1800.0	366.0	80.0	800.0
161.0	TERM 42 BEND TERMINATOR	R- 20	1.7	25.3	25.3	1.5	1.51	.99					
157.3	TERM 43 BEND TERMINATOR	B- 26	.4	32.1	32.1	1.5	1.07	.64	.20	1400.0	340.0	80.0	800.0
156.9	TERM 44 BEND TERMINATOR	B- 27	1.5	30.4	30.4	1.5	1.16	.73	.20	5000.0	349.0	80.0	800.0

(Continued)

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Table 12 (Continued)

RIVER POINTS			REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
157.4	TERM 45	BEND TERMINATOR	R- 21	1.3	24.5	24.5	1.5	1.51	.99					
156.1	TERM 46	BEND TERMINATOR	B- 28	1.0	29.6	29.6	1.5	1.03	.71	.20	4000.0	378.0	80.0	800.0
155.1	TERM 47	BEND TERMINATOR	R- 22	4.3	27.6	27.6	1.5	1.51	.99					
152.8	TERM 48	BEND TERMINATOR	B- 29	1.8	26.6	26.6	1.5	1.05	.62	.20	1000.0	364.0	80.0	800.0
149.0	TERM 49	BEND TERMINATOR	R- 23	1.8	28.5	28.5	1.5	1.51	.99					
147.2	TERM 50	BEND TERMINATOR	B- 30	.2	25.4	25.4	1.5	1.05	.62	.20	500.0	500.0	60.0	800.0
147.0	TERM 51	BEND TERMINATOR	B- 31	.7	22.2	22.2	1.5	1.10	.66	.20	2000.0	552.0	80.0	800.0
146.3	TERM 52	BEND TERMINATOR	B- 32	2.1	26.0	26.0	1.5	1.04	.61	.20	800.0	450.0	60.0	800.0
144.2	TERM 53	BEND TERMINATOR	R- 24	2.3	31.2	31.2	1.5	1.51	.99					
141.3	TERM 54	BEND TERMINATOR	B- 33	1.3	31.1	31.1	1.5	1.65	.62	.20	1000.0	450.0	60.0	800.0
140.0	TERM 55	BEND TERMINATOR	B- 34	.5	31.0	31.0	1.5	1.10	.66	.20	1900.0	522.0	80.0	800.0
139.5	TERM 56	BEND TERMINATOR	R- 25	1.3	34.5	34.5	1.5	1.51	.99					
138.2	TERM 57	BEND TERMINATOR	B- 35	.4	38.4	38.4	1.5	.35	.27	.20	1100.0	565.0	80.0	800.0
137.8	TERM 58	BEND TERMINATOR	R- 26	1.4	38.0	38.0	1.5	1.51	.99					
136.4	TERM 59	BEND TERMINATOR	B- 36	.4	37.0	37.0	1.5	1.00	.64	.20	1500.0	500.0	80.0	800.0
136.0	TERM 60	BEND TERMINATOR	B- 37	1.5	36.0	36.0	1.5	1.05	.62	.20	900.0	350.0	80.0	800.0
134.5	TERM 61	BEND TERMINATOR	B- 38	1.1	35.0	35.0	1.5	1.16	.71	.20	3000.0	400.0	80.0	800.0
133.4	TERM 62	BEND TERMINATOR	R- 27	3.2	34.8	34.8	1.5	1.51	.99					
130.2	TERM 63	BEND TERMINATOR	B- 39	.6	34.1	34.1	1.5	.70	.50	.20	2600.0	482.0	80.0	800.0
129.6	TERM 64	BEND TERMINATOR	R- 28	13.0	40.0	40.0	1.5	1.51	.99					
116.6	LOCK 2	COFFEEVILLE L&D	R- 29	1.0	20.0	20.0	1.5	1.51	.99					
115.6	TERM 65	BEND TERMINATOR	B- 40	.7	20.8	20.8	1.5	1.16	.71	.20	3000.0	300.0	80.0	800.0
114.9	TERM 66	BEND TERMINATOR	R- 30	6.9	17.1	17.1	1.5	1.51	.99					
108.0	TERM 67	BEND TERMINATOR	B- 41	1.7	12.9	12.9	1.5	1.05	.62	.20	1000.0	239.0	80.0	600.0
106.3	TERM 68	BEND TERMINATOR	R- 31	2.0	17.0	17.0	1.5	1.51	.99					
104.3	TERM 69	BEND TERMINATOR	B- 42	1.3	18.0	18.0	1.5	1.09	.65	.20	1700.0	550.0	80.0	800.0
103.0	TERM 70	BEND TERMINATOR	R- 32	4.3	19.0	19.0	1.5	1.27	.86					
98.7	TERM 71	BEND TERMINATOR	B- 43	.9	19.1	19.1	1.5	.92	.64	.20	3500.0	340.0	80.0	800.0
97.8	TERM 72	BEND TERMINATOR	R- 33	2.1	25.5	25.5	1.5	1.51	.99					
95.7	TERM 73	BEND TERMINATOR	B- 44	.9	23.0	23.0	1.5	.60	.48	.20	2500.0	400.0	80.0	600.0
94.8	TERM 74	BEND TERMINATOR	R- 34	1.4	21.8	21.8	1.5	1.51	.99					
93.4	TERM 75	BEND TERMINATOR	B- 45	1.3	20.5	20.5	1.5	1.18	.73	.20	3500.0	300.0	80.0	600.0
92.1	TERM 76	BEND TERMINATOR	R- 35	1.8	19.3	19.3	1.5	1.51	.99					
90.3	TERM 77	BEND TERMINATOR	B- 46	.9	18.0	18.0	1.5	.49	.36	.20	1700.0	300.0	80.0	800.0
[illegible]	TERM 78	BEND TERMINATOR	R- 36	.7	16.8	16.8	1.5	1.51	.99					
88.7	TERM 79	BEND TERMINATOR	B- 47	1.2	15.5	15.5	1.5	.99	.60	.20	3000.0	400.0	80.0	800.0
87.5	TERM 80	BEND TERMINATOR	B- 48	1.5	14.3	14.3	1.5	1.16	.71	.20	3000.0	400.0	80.0	800.0
86.0	TERM 81	BEND TERMINATOR	B- 49	1.7	13.0	13.0	1.5	1.09	.66	.20	1000.0	200.0	80.0	800.0
84.3	TERM 82	BEND TERMINATOR	B- 50	.9	11.7	11.7	1.5	1.13	.68	.20	2500.0	373.0	80.0	800.0
83.4	TERM 83	BEND TERMINATOR	B- 51	1.4	14.1	14.1	1.5	1.10	.66	.20	2000.0	333.0	80.0	800.0
82.0	TERM 84	BEND TERMINATOR	B- 52	2.0	14.0	14.0	1.5	1.07	.64	.20	1400.0	350.0	80.0	800.0
80.0	TERM 85	BEND TERMINATOR	B- 53	1.0	15.0	15.0	1.5	1.16	.71	.20	3000.0	450.0	80.0	800.0
79.0	TERM 86	BEND TERMINATOR	R- 37	2.0	15.5	15.5	1.5	1.51	.99					
77.0	TERM 87	BEND TERMINATOR	B- 54	1.0	15.6	15.6	1.5	1.21	.75	.20	4000.0	351.0	80.0	800.0
76.0	TERM 88	BEND TERMINATOR	R- 38	.5	13.5	13.5	1.5	1.51	.99					
75.5	TERM 89	BEND TERMINATOR	B- 55	1.6	11.4	11.4	1.5	1.16	.71	.20	3000.0	347.0	80.0	800.0

(Continued)

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Table 12 (Continued)

RIVER POINTS			REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
73.9	TERM 90	BEND TERMINATOR	B- 56	1.4	14.3	14.3	1.5	.56	.41	.20	2000.0	295.0	80.0	800.0
72.5	TERM 91	BEND TERMINATOR	B- 57	.8	16.7	16.7	1.5	1.10	.66	.20	2000.0	422.0	80.0	800.0
71.7	TERM 92	BEND TERMINATOR	B- 58	1.6	19.3	19.3	1.5	.56	.41	.20	2000.0	350.0	80.0	800.0
70.1	TERM 93	BEND TERMINATOR	B- 59	1.6	13.7	13.7	1.5	.70	.50	.20	2600.0	304.0	80.0	800.0
68.5	TERM 94	BEND TERMINATOR	R- 39	1.0	14.5	14.5	1.5	1.51	.99					
67.5	TERM 95	BEND TERMINATOR	B- 60	1.3	15.3	15.3	1.5	1.12	.68	.20	2300.0	290.0	80.0	800.0
66.2	TERM 96	BEND TERMINATOR	R- 40	2.1	16.0	16.0	1.5	1.51	.99					
64.1	TERM 97	BEND TERMINATOR	B- 61	.5	16.5	16.5	1.5	1.10	.66	.20	2000.0	400.0	80.0	800.0
63.6	TERM 98	BEND TERMINATOR	B- 62	1.4	17.0	17.0	1.4	1.09	.65	.20	1700.0	500.0	80.0	800.0
62.2	TERM 99	BEND TERMINATOR	R- 41	1.7	17.0	17.0	1.5	1.51	.99					
60.5	TERM100	BEND TERMINATOR	B- 63	.9	17.6	17.6	1.5	1.08	.64	.20	1500.0	401.0	80.0	800.0
59.6	TERM101	BEND TERMINATOR	R- 42	3.6	22.0	22.0	1.5	1.51	.99					
56.0	TERM102	BEND TERMINATOR	B- 64	.7	27.9	27.9	1.5	1.06	.63	.20	1100.0	471.0	80.0	800.0
55.3	TERM103	BEND TERMINATOR	R- 43	4.3	27.5	27.5	1.5	1.51	.99					
51.0	TERM104	BEND TERMINATOR	B- 65	.8	27.0	27.0	1.5	1.10	.66	.20	1900.0	500.0	80.0	800.0
50.2	TERM105	BEND TERMINATOR	R- 44	1.2	26.5	26.5	1.5	1.51	.99					
49.0	TERM106	BEND TERMINATOR	B- 66	.5	26.4	26.4	1.5	.49	.36	.20	1700.0	611.0	80.0	800.0
48.5	TERM107	BEND TERMINATOR	R- 45	3.5	26.5	26.5	1.5	1.51	.99					
45.0	PORT 3	ALABAMA R FLEETING												

SECTOR 30 MOBILE RIVER

RIVER POINTS			REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
45.0	PORT 1	ALABAMA R FLEETING	R- 1	5.7	27.0	27.0	1.5	1.51	.99					
39.3	TERM 1	BEND TERMINATOR	B- 1	1.1	28.6	28.6	1.5	.35	.27	.20	1100.0	459.0	80.0	800.0
38.2	TERM 2	BEND TERMINATOR	R- 2	1.3	28.0	28.0	1.5	1.51	.99					
36.9	TERM 3	BEND TERMINATOR	B- 2	.4	26.9	26.9	1.5	1.08	.64	.20	1500.0	440.0	80.0	800.0
36.5	TERM 4	BEND TERMINATOR	R- 3	1.2	27.5	27.5	1.5	1.51	.99					
35.3	TERM 5	BEND TERMINATOR	B- 3	2.3	28.0	28.0	1.5	1.10	.66	.20	1900.0	400.0	80.0	800.0
33.0	TERM 6	BEND TERMINATOR	R- 4	.7	28.5	28.5	1.5	1.51	.99					
32.3	TERM 7	BEND TERMINATOR	B- 4	.6	28.5	28.5	1.5	1.08	.64	.20	1500.0	400.0	80.0	800.0
31.7	TERM 8	BEND TERMINATOR	R- 5	1.2	29.0	29.0	1.5	1.51	.99					
30.5	PORT 2	MOBILE RIVER	R- 6	2.5	29.0	29.0	1.5	1.51	.93					
28.0	TERM 9	BEND TERMINATOR	B- 5	2.0	28.2	28.2	1.5	1.05	.62	.20	900.0	466.0	80.0	800.0
26.0	TERM 10	BEND TERMINATOR	R- 7	2.0	31.0	31.0	1.5	1.51	.93					
24.0	TERM 11	BEND TERMINATOR	B- 6	2.3	33.2	33.2	1.5	1.05	.62	.20	1000.0	507.0	80.0	800.0
21.7	TERM 12	BEND TERMINATOR	R- 8	8.1	34.0	34.0	1.5	1.51	.93					
13.6	TERM 13	BEND TERMINATOR	B- 7	2.0	35.0	35.0	1.5	1.03	.71	.20	4000.0	146.0	80.0	800.0
11.6	TERM 14	BEND TERMINATOR	R- 9	11.6	36.0	36.0	1.5	1.51	.93					
0.	PORT 3	APE MOBILE AREA												

RIVER SYSTEM 10 BLACK WARRIOR RIVER (16)

SECTOR 27 BLACK WARRIOR RIVER

RIVER POINTS			REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
0.	PORT 1	BANKHEAD POOL	R- 1	30.7	10.5	10.5	1.5	.92	.92					

(Continued)

(Sheet 9 of 10)

Table 12 (Concluded)

RIVER POINTS				REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
30.7	LOCK	1	BANKHEAD L&D	R- 2	9.1	10.5	10.5	1.5	.92	.92					
39.8	PORT	2	HOLT POOL	R- 3	9.4	10.5	10.5	1.5	.92	.92					
49.2	LOCK	2	HOLT L&D	R- 4	1.2	10.5	10.5	1.5	.92	.92					
50.4	PORT	3	OLIVER POOL	R- 5	7.7	10.5	10.5	1.5	.92	.92					
58.1	LOCK	3	OLIVER L&D	R- 6	1.1	10.5	10.5	1.5	.92	.92					
59.2	PORT	4	WARRIOR POOL	R- 7	75.9	10.5	10.5	1.5	.92	.92					
135.1	LOCK	4	WARRIOR L&D	R- 8	44.1	10.5	10.5	1.5	.92	.92					
179.2	PORT	5	TTW/BLCK WARR FLEET												

RIVER SYSTEM 19 TENN-TOM WATERWAY (19)

SECTOR 26 TENNESSEE-TOMBIGBEE

RIVER POINTS				REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
0.	PORT	1	APE TENN R/TTW FLTG	R- 1	39.3	12.0	12.0	0.	1.00	1.00					
39.3	LOCK	1	BAY SPRINGS LOCK	R- 2	5.2	12.0	12.0	0.	1.00	1.00					
44.5	LOCK	2	LOCK E (TENN-TOM)	R- 3	8.3	12.0	12.0	0.	1.00	1.00					
52.8	LOCK	3	LOCK D (TENN-TOM)	R- 4	7.4	12.0	12.0	0.	1.00	1.00					
60.2	LOCK	4	LOCK C (TENN-TOM)	R- 5	14.7	12.0	12.0	0.	1.00	1.00					
74.9	LOCK	5	LOCK B (TENN-TOM)	R- 6	5.2	12.0	12.0	0.	1.00	1.00					
80.1	LOCK	6	LOCK A (TENN-TOM)	R- 7	6.8	10.0	10.0	1.0	1.00	1.00					
86.9	PORT	2	ABERDEEN TTW CO	R- 8	6.8	10.0	10.0	1.0	1.00	1.00					
93.7	LOCK	7	ABERDEEN L&D	R- 9	0.	10.0	10.0	1.0	1.00	1.00					
93.7	PORT	3	COLUMBUS POOL	R- 10	22.6	10.0	10.0	1.0	1.00	1.00					
116.3	LOCK	8	COLUMBUS L&D	R- 11	0.	10.0	10.0	1.0	1.00	1.00					
116.3	PORT	4	ALICEVILLE POOL	R- 12	27.9	10.0	10.0	1.0	1.00	1.00					
144.2	LOCK	9	ALICEVILLE L&D	R- 13	0.	10.0	10.0	1.0	1.00	1.00					
144.2	PORT	5	GAINSVILLE POOL	R- 14	39.9	10.0	10.0	1.0	1.00	1.00					
184.1	LOCK	10	GAINESVILLE L&D	R- 15	48.1	10.0	10.0	1.0	1.00	1.00					
232.2	PORT	6	TTW/BLCK WARR FLEET												

RIVER SYSTEM 20 GREEN-BARREN RIVERS (20)

SECTOR 8 GREEN & BARREN RIVER

RIVER POINTS				REACH OR BEND	LENGTH (MI)	DEPTH (FT) AVG	DEPTH (FT) MIN	CURRENT (MPH)	COEFFICIENTS UP	COEFFICIENTS DN	COEFFICIENTS FL	BEND RADIUS (FT)	BEND WIDTH (FT)	CLEARANCE WIDTH (FT)	FLANKING LENGTH (FT)
0.	PORT	1	APE GREEN POOLS 2-3	R- 1	46.7	20.0	11.0	.5	.65	.65					
46.7	PORT	2	1005 GREEN POOL 1	R- 2	40.6	20.0	11.0	.5	.65	.65					
87.3	PORT	3	GREEN RIVER FLEETNG												

(Sheet 10 of 10)

Table 13

Routing Table

D-12

FROM SECTOR	TO SECTOR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D
2	U- 1-U		D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D
3	U- 2-U	U- 2-U		D- 4-U	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D
4	D- 3-U	D- 3-U	D- 3-U		D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D
5	U- 3-U	U- 3-U	U- 3-U	U- 4-U		D- 6-U	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D
6	D- 5-U	D- 5-U	D- 5-U	D- 5-U	D- 5-U		D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D
7	U- 5-U	U- 5-U	U- 5-U	U- 5-U	U- 5-U	U- 6-U		D- 8-U	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D
8	D- 7-U	D- 7-U	D- 7-U	D- 7-U	D- 7-U	D- 7-U	D- 7-U		D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D
9	U- 7-U	U- 7-U	U- 7-U	U- 7-U	U- 7-U	U- 7-U	U- 7-U	U- 8-U		D-14-U	D-14-U	D-14-U	D-14-U	D-14-U	D-15-D
10	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D		D-13-U	D-13-U	D-13-U	D-14-D	D-14-D
11	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D		D-12-D	D-12-D	D-12-D	D-12-D
12	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	U-11-U		D-13-D	D-13-D	D-13-D
13	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-10-U	U-12-U	U-12-U		D-14-D	D-14-D
14	D- 9-U	D- 9-U	D- 9-U	D- 9-U	D- 9-U	D- 9-U	D- 9-U	D- 9-U	D- 9-U	U-10-U	U-13-U	U-13-U	U-13-U		D-15-D
15	U- 9-U	U- 9-U	U- 9-U	U- 9-U	U- 9-U	U- 9-U	U- 9-U	U- 9-U	U- 9-U	U-14-U	U-14-U	U-14-U	U-14-U	U-14-U	
16	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D
17	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D
18	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D
19	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D
20	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U
21	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U	U-15-U
22	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U
23	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U
24	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U
25	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U
26	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-12-U	U-12-U	U-13-D	U-13-D	U-13-D
27	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U
28	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U
29	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U
30	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U
31	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U
32	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U
33	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D
34	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-32-D

(Continued)

(Sheet 1 of 3)

Table 13 (Continued)

FROM SECTOR	TO SECTION 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D	D- 2-D
2	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D	D- 3-D
3	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D
4	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D	D- 5-D
5	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D
6	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D	D- 7-D
7	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D
8	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D	D- 9-D
9	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-14-U	D-14-U	D-14-U	D-14-U	D-14-U	D-14-U
10	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-13-U	D-13-U	D-13-U	D-13-U	D-13-U	D-13-U
11	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D	D-12-D
12	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-13-D	D-26-D	D-26-D	D-26-D	D-26-D	D-26-D	D-26-D
13	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	D-14-D	U-26-D	U-26-D	U-26-D	U-26-D	U-26-D	U-26-D
14	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	D-15-D	U-13-U	U-13-U	U-13-U	U-13-U	U-13-U	U-13-U
15	D-20-U	D-20-U	D-20-U	D-20-U	D-20-U	D-21-D	D-21-D	D-21-D	D-21-D	U-14-U	U-14-U	U-14-U	U-14-U	U-14-U	U-14-U
16		D-17-U	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D
17	D-16-U		D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D	D-18-D
18	U-16-U	U-17-U		D-19-U	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D
19	D-18-U	D-18-U	D-18-U		D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D	D-20-D
20	U-18-U	U-18-U	U-18-U	U-19-U		D-21-D	D-21-D	D-21-D	D-21-D	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U	D-15-U
21	U-20-U	U-20-U	U-20-U	U-20-U	U-20-U		D-22-U	D-23-D	D-23-D	D-23-D	U-15-U	D-23-D	D-23-D	D-23-D	D-23-D
22	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U	D-21-U		D-23-D	D-23-D	D-23-D	D-21-U	D-23-D	D-23-D	D-23-D	D-23-D
23	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-21-U	U-22-U		D-24-U	D-32-U	D-32-U	D-32-U	D-32-U	D-32-U	D-32-U
24	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U		D-32-U	D-32-U	D-32-U	D-32-U	D-32-U	D-32-U
25	D-30-U	D-30-U	D-30-U	D-30-U	D-30-U	D-31-D	D-31-D	D-31-D	D-31-D		D-30-U	D-30-U	D-30-U	D-30-U	D-30-U
26	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	U-13-D	D-28-D	D-28-D	D-28-D		D-27-U	D-28-D	D-28-D	D-28-D
27	D-26-U	D-26-U	D-26-U	D-26-U	D-26-U	D-28-D	D-28-D	D-28-D	D-28-D	D-28-D	D-26-U		D-28-D	D-28-D	D-28-D
28	U-26-U	U-26-U	U-26-U	U-26-U	U-26-U	D-30-D	D-30-D	D-30-D	D-30-D	D-30-D	U-26-U	U-27-U		D-30-D	D-30-D
29	D-28-U	D-28-U	D-28-U	D-28-U	D-28-U	D-30-D	D-30-D	D-30-D	D-30-D	D-30-D	D-28-U	D-28-U	D-28-U		D-30-D
30	U-28-U	U-28-U	U-28-U	U-28-U	U-28-U	D-31-D	D-31-D	D-31-D	D-31-D	D-25-U	U-28-U	U-28-U	U-28-U	U-29-U	
31	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U	D-32-D	D-32-D	D-32-D	D-32-D	U-25-U	U-30-U	U-30-U	U-30-U	U-30-U	U-30-U
32	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-23-U	D-24-U	U-31-U	U-31-U	U-31-U	U-31-U	U-31-U	U-31-U
33	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U	D-31-U
34	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D	D-32-D

(Continued)

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Table 13 (Concluded)

FROM SECTOR	TO SECTOR 31	32	33	34
1	D- 2-D	D- 2-D	D- 2-D	D- 2-D
2	D- 3-D	D- 3-D	D- 3-D	D- 3-D
3	D- 5-D	D- 5-D	D- 5-D	D- 5-D
4	D- 5-D	D- 5-D	D- 5-D	D- 5-D
5	D- 7-D	D- 7-D	D- 7-D	D- 7-D
6	D- 7-D	D- 7-D	D- 7-D	D- 7-D
7	D- 9-D	D- 9-D	D- 9-D	D- 9-D
8	D- 9-D	D- 9-D	D- 9-D	D- 9-D
9	D-14-U	D-14-U	D-15-D	D-14-U
10	D-13-U	D-13-U	D-14-D	D-13-U
11	D-12-D	D-12-D	D-12-D	D-12-D
12	D-26-D	D-26-D	D-13-D	D-26-D
13	U-26-D	U-26-D	D-14-D	U-26-D
14	U-13-U	U-13-U	D-15-D	U-13-U
15	U-14-U	U-14-U	D-21-D	U-14-U
16	D-18-D	D-18-D	D-18-D	D-18-D
17	D-18-D	D-18-D	D-18-D	D-18-D
18	D-20-D	D-20-D	D-20-D	D-20-D
19	D-20-D	D-20-D	D-20-D	D-20-D
20	D-15-U	D-15-U	D-21-D	D-15-U
21	D-23-D	D-23-D	D-23-D	D-23-D
22	D-23-D	D-23-D	D-23-D	D-23-D
23	D-32-U	D-32-U	D-32-U	D-32-U
24	D-32-U	D-32-U	D-32-U	D-32-U
25	D-31-D	D-31-D	D-31-D	D-31-D
26	D-28-D	D-28-D	D-28-D	D-28-D
27	D-28-D	D-28-D	D-28-D	D-28-D
28	D-30-D	D-30-D	D-30-D	D-30-D
29	D-30-D	D-30-D	D-30-D	D-30-D
30	D-31-D	D-31-D	D-31-D	D-31-D
31		D-32-D	D-33-U	D-34-U
32	U-31-U		U-33-U	U-34-U
33	D-31-U	D-32-D		D-34-U
34	D-31-U	D-32-D	D-33-U	

(Sheet 3 of 3)

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